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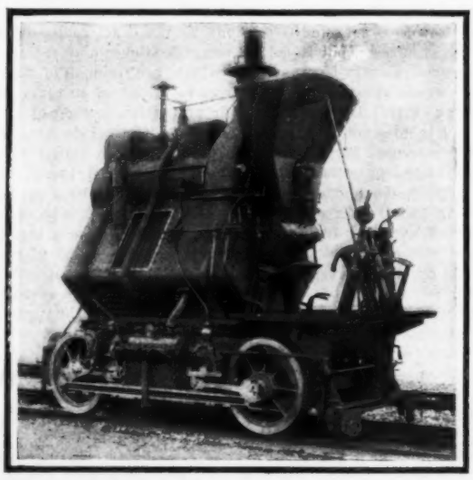
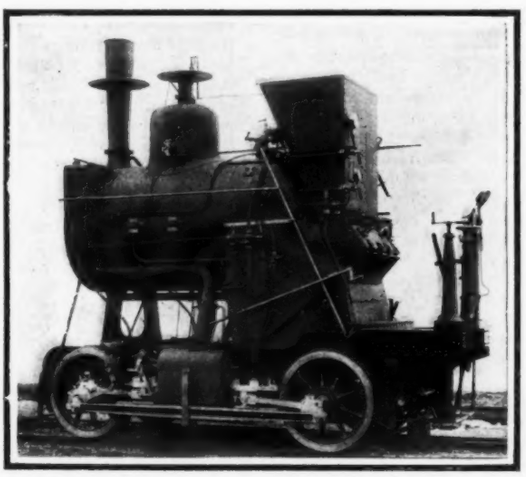
THE MAFFEI STEAM MOTOR COACH.

By the English Correspondent of SCIENTIFIC AMERICAN.

THERE has recently been acquired by the Bavarian state railroads, for the haulage of motor coaches over short-distance routes, a new type of steam motor which embodies several novel features. This recent engine is the invention of the well-known engineering firm of J. A. Maffei of Munich. The coach, as may be seen from the accompanying illustration, follows the general lines adopted in this class of motor railroad rolling stock, in which the engine is carried upon a separate bogie, independent of the frame of the car, so as to admit of easy and ready detachment from the body of the carriage for overhauling and repair.



Maffei Steam Motor with Water Tube Boiler. In This Picture it will be Observed that the Smokestack is Brought to the Front Because of the Action of the Flames.



The Engine of the Maffei Coach, Showing Cylinder and Method of Coupling Wheels; Also Coal Bunker, which Feeds Into the Fire.

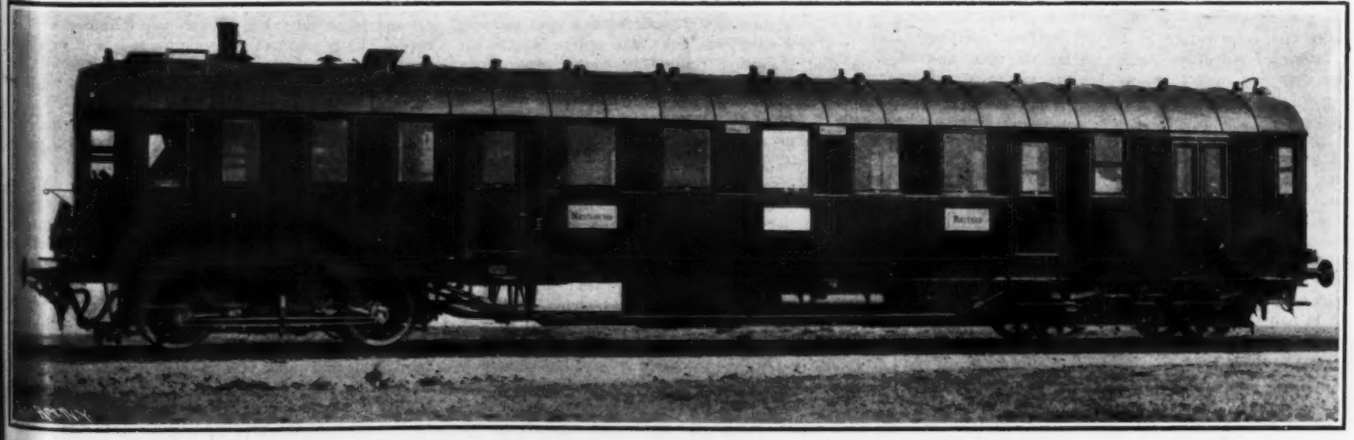
The distinctive feature of the coach is the engine. There is a cylinder placed on each side of the boiler, and in these are two pistons working in opposite directions, each connected independently by its own crossheads and connecting rods to the front and rear pair of wheels respectively. The object and advantage of this arrangement is the elimination of the disturbances arising from the undivided thrust of the reciprocating masses, which in steam-propelled coaches of this class it is advisable to reduce to the minimum. In this arrangement the oscillations arising from side lash, that is, horizontal displacements about a vertical axis, are overcome. A noticeable advantage is that the cranks on each side of the engine attain their maximum power at four different points in the course of a revolution, as compared with only two in ordinary locomotive practice. Owing to the shortness of the connecting rods, which are only some 26½ inches in length, these points stand at an angle of 78½ deg. from the piston line, while there is a difference of 23 deg. between the points of maximum crank power of the front and back cranks respectively. The cylinders are of 8 inches diameter, and the length of stroke is 2 x 10¼ inches. The driving wheels have a diameter of 39 3/5 inches.

Superheated steam is employed, piston valves operated by a compact and novel design of Walschaert gear serving to effect the steam distribution to the cylinders. There is a single eccentric driving the expansion link in place of the usual crank valve. The lead lever is operated from a link attached direct to the center of the crosshead, in lieu of the bracket attached to the piston crosshead and oscillated in the general practice of locomotive design. The connecting rods are made with forked ends fitted with a block, and are mounted on the driving-wheel pins close up to the wheels. Outside of these are special coupling-rod cranks, coupling rods being utilized in order to synchronize the two motions back and front. The boiler is of the latest locomotive type. At the rear of the firebox is a bunker containing the coal, and from which the fuel falls on to the fire as required. The rate of feed is regulated by means of traps, while furthermore suitable orifices are provided in the inclined firedoors for the purpose of observing the fire. The grate area is 9.36 square feet; the heating surface of firebox, 37.25 square feet; the heating surface of tubes, 404.8 square feet, while the heating surface of superheater in contact with the gases of combustion is 74.81 square feet, giving a total heating surface of 529.50 square feet. The capacity of the coal bunkers is 1,322.77 pounds, and of the water tanks 880 gallons. The working steam pressure is 235 pounds per square inch, while the tractive effort is 3,706.76 pounds.

The coach to which this motor is fitted has a total length of nearly 67 feet, with a width of 9 feet 8 inches, and a height of about 15 feet maximum. The total wheel base is approximately 52 feet 6 inches, and the rigid wheel base 9 feet 2 inches. It is of one class only, and there is seating accommodation for 55 persons, with standing room for another 30, making 85 in all. The coach is divided into two compartments, together with a space for the conductor and the baggage. The motor is carried in a compartment in the fore part of the train with the engine reversed, i. e., the foot plate in front of the boiler, so that the engineer has an uninterrupted view through the whole of the end of the coach, the control levers being placed in front of him. This brings the smokestack to the rear of the engine room. Only one engineer is carried, and the car can only be driven from one end.

The total weight of the locomotive is approximately 47.4 tons empty, and 53 tons in working order, and the trailer 40 tons. When the exigencies of the traffic so require, two trailing coaches can be attached and a speed of 40 miles per hour maintained, the maximum speed being 47 miles per hour. The maximum power developed by the motor is 360 horse-power. The coal consumption when working on the level varies between 17 and 21 pounds per mile, but it must be remembered that the fuel generally available is the relatively inferior coal obtained from German collieries.

Owing to the unique success that has attended the



THE MAFFEI STEAM-PROPELLED RAILROAD COACH, SHOWING THE DRIVING WHEELS OF THE FORWARD BOGIE.

system evolved by Mr. J. A. Maffei, it is being widely adopted upon the railroads of Bavaria. One or two improvements and modifications have however been incorporated, since in some instances the coaches are intended for running upon local light roads. The most important alteration is the removal of the coupling rods in the tank locomotives. The water-tube boiler is also being employed in some instances in lieu of the ordinary locomotive type. In such cases, instead of placing the chimney at the rear of the engine room in the motor coach, it is placed at the front end, immediately behind the foot plate.

DUST PREVENTIVES.*

THE TEMPORARY TAR AND OIL BINDERS, EMULSIONS AND SIMILAR PREPARATIONS.

BY PREVOST HUBBARD.

For the sake of convenience tars and oils will be considered under two headings, according to the condition in which they are applied. The first class will comprise those materials which are applied in their natural state, and the second those which are applied in the form of water emulsions. Materials of both classes are most easily and satisfactorily applied by means of an ordinary watering cart and usually upon the unprepared road. As in the case of water and salt solutions, a number of applications at more or less frequent intervals is generally necessary to lay the dust for a season.

MATERIALS APPLIED IN THEIR NATURAL CONDITION.

Among those materials which are applied in their natural condition are some which exhibit no actual road-building qualities, while others are to be found which contain a relatively small quantity of the substances which have been considered in preceding papers as permanent binders. The former act merely as palliatives and lay the dust in much the same manner as water, by wetting, or, in this case, oiling the dust particles to such an extent that they are held together by force of capillarity. Vegetable oils, paraffin petroleums, and certain tar oils, such as the heavy, dead, or creosote oils, belong to this class of materials. Their effect is of longer duration than that of water owing to the fact that they evaporate much more slowly. Like water, they have a definite point of saturation for the dust particles, and when this point is passed the road again begins to grow dusty. If they are present in too great an amount, a soft, greasy surface condition is produced, which is very undesirable. Heavy rains are apt to wash them out of the road, and the presence of water upon road surfaces to which they have been applied is productive of an oily, disagreeable mud under the action of traffic, and pools of oily water form in any ruts or depressions which may exist. They have been tried in many places, and, while they have proved to be fairly efficient dust layers, the disagreeable results produced in wet weather and the fact that they do not improve the road permanently have brought their use into general discredit.

The oils and tars which contain a certain amount of true binding base are much to be preferred for the purpose of dust laying to the materials just described. While for the most part they volatilize slowly, they nevertheless leave behind upon evaporation some binding material which is not removed by water and which tends to harden and bind together the surface cushion of fine material. Successive applications result in an accumulation of this binding material, and at the end of a season's treatment a very noticeable improvement in the wearing quality of the road surface is found to exist, and in some cases the resulting condition is similar to that produced by a single application of a permanent binder containing the same kind of base. A material of this kind holds an intermediate position between the palliatives and the permanent binders and possesses some of the qualities of each. The volatile oils, constituting by far the greatest portion, act through force of capillarity to lay the dust, and when they are evaporated or become saturated another application is required. At the same time the true binding base present actually cements some of the loose particles together and, as it works into the road proper, produces the results already described. If too heavy an application is made at one time the road surface will become soft and greasy and easily rutted, or if an appreciable amount of a non-binding base, such as paraffin, is present, as in the case of some semi-asphaltic petroleums, the same disagreeable mud will be formed in wet weather as that produced by the oil palliatives. Besides being disagreeable, this mud is ruinous to clothes and the paint and varnish on vehicles. In both cases the oil is apt to prove injurious to rubber tires.

Water-gas tar is perhaps one of the best temporary binders that can be applied in its natural state, although it has not been very generally employed. It can be obtained for about 3 cents a gallon, and when applied at the rate of 0.3 gallon per square yard on an ordinary macadam road will lay the dust successfully for some time. The number of applications required during a season will, of course, depend upon various conditions, but under ordinary circumstances a comparatively few will suffice. This material is readily absorbed by the road, and contains a sufficient amount of pitch to reduce dust formation to a considerable extent. It has a rather objectionable gassy odor, which, however, soon disappears. When used on roads having a great amount of fine material it is sometimes necessary to apply more than 0.3 gallon per square yard. In a case of this sort the tar does not bind the dust down firmly to the underlying surface, but it holds the particles well together and keeps them from being raised by passing vehicles or winds. Under the action of traffic, this loose or shifting surface is alternately compacted and broken up, but it does not form a disagreeable mud. During rainy weather, in fact, it has been known to produce a compact, uniform surface, which appears to advantage in comparison with the surface in dry weather. In localities where water-gas tar can be readily obtained with but little cost for transportation it can undoubtedly be used to advantage, and in many cases should successfully compete with other temporary binders.

Besides water-gas tar some of the lighter semi-asphaltic oils in their crude condition may be applied as temporary binders, as has already been indicated. When not too much paraffin is present, the residue left upon the road after the volatile constituents have evaporated forms a permanent binder. Successive applications will therefore result in a condition similar to that obtained by the single application of a heavy asphaltic oil, and the wearing quality of the road will be improved. As an example of a preparation insoluble in water which may be employed in its original condition might be mentioned a mixture of creosote, shale, or other mineral oil, and coal tar.

In regard to method of application, it may be said that in general the best method of applying to a road surface this kind of material or, in fact, any temporary binder is the same as that described for calcium chloride; that is, the middle of the road is given twice as heavy treatment as the sides, owing to the tendency of the material to be carried to the sides by gravitation and by running water. Of course the system described under the subject of calcium chloride for diluting concentrated material is only applicable to those substances miscible with water, as in the case of emulsions, which will next be considered.

EMULSIONS OF OILS WITH WATER.

Emulsions of oils or fats with water may be made either by mechanical or chemical means.

Chemical emulsions have up to the present been most generally used for the purpose of dust prevention, but before considering them it may be well to mention an apparatus which has recently been devised for the purpose of spreading a mechanical mixture of oily substances and water upon a road surface. This is a cart with two tanks, one containing the oil or tar and the other containing water. These two substances are led through pipes into a box where they are thoroughly mixed by means of rapidly whirling blades, which also force the mixture upon the road in the form of a spray. The water either evaporates or is rapidly absorbed by the road, thus leaving the tar or oil in a fine film over the surface, where it acts both as a binder and a dust layer. The number of applications required during a season will, of course, depend upon the character of the binder and quantity employed at each application, as well as upon local conditions. This method of application has proved satisfactory in some English experiments, but it has so far not been employed to a sufficient extent to warrant a general recommendation. It has some advantages over the chemical method of forming emulsions which will now be described.

Chemical emulsions are oily substances made miscible with water through the agency of saponifying materials. These saponifying materials react with a part of the fats or oils to form more or less soluble soaps, solutions of which are capable of mixing with oils and tars. Alkalies, such as potash or soda, are probably the most widely known saponifying agents, but other substances may be employed for the same purpose. Ammonia and also crude carbolic acid have been used to a considerable extent in preparing emulsions for the purpose of laying dust. In some cases no direct saponifying materials have been added to the oily material, but cheap soap solutions have been used instead. A number of these oil and tar emulsions have appeared on the market during recent years, and many have given good results when properly applied.

It is quite impossible to describe all of these preparations, as the exact composition of most of them is kept secret by the manufacturers. A few simple mixtures which are typical of these preparations will, however, be presented in order to give a general idea of their properties, method of application, and the results obtained from their use. In preparing an article of this sort, it is usually the endeavor of the manufacturer to produce a material which will contain the maximum amount of binding material per unit volume and at the same time be economical. Waste products from the various arts can frequently be utilized in these preparations, and of course tend to cheapen the material. Deliquescent substances, such as calcium chloride and certain soluble resinates, are sometimes incorporated in the preparations for the purpose of retaining moisture, while in others certain chemicals are employed for the purpose of oxidizing or hardening the binder upon evaporation of the volatile constituents. Before taking up the separate types in detail, it may be said in regard to their application that all are dependent upon a convenient water supply. As it is necessary to dilute them before using, a method similar to that described for calcium chloride, by which portions are first distributed at the different hydrants along the road, is the one which is likely to prove most economical.

The first type of emulsion which will be considered is the asphaltic or semi-asphaltic oil emulsion, which has in this country undoubtedly been used to a greater extent than any other. In some of our large cities these emulsions have been prepared under the supervision of the experimenter, in which case a soap solution has generally been employed to emulsify crude oils containing asphaltic bases. In other cases special preparations have been purchased which contain a residual asphaltic or semi-asphaltic oil emulsified by means of saponifying agents.

In Boston a number of the park roads are treated with an emulsion prepared as follows: To every 50 gallons of water 18 pounds of cotton-seed oil soap, costing 4½ cents per pound, are added, and the solution is hastened by the application of steam heat. This solution may be made in barrels and afterward pumped into the sprinkling wagons or into a reservoir. One hundred gallons of crude petroleum is then added to every 50 gallons of soap solution and the mixture is agitated until emulsification is complete. The emulsion thus produced contains about 66 per cent oil and is considerably diluted before applying to the road. The percentage of asphaltic base will of course depend upon the amount contained in the original oil. A 16 per cent oil solution is applied to the road at first, and the succeeding applications vary from 5 to 10 per cent, according to the needs of the road. The number of applications required during a season will vary with conditions. They are usually made, however, from ten to twenty-five days apart. By the use of a soap emulsion of this kind the loose material on the road is held down, but is not bound firmly together nor to the road surface. A thin rolling cushion is produced, saturated with oil, which prevents dust formation and protects the underlying surface. A very light coating of sand or fine stone screenings is sometimes spread on the road before applying the emulsion. This produces a cushion which will be hard and firm and take a considerable amount of wear. The main objection to this thin rolling cushion is that under the action of traffic it is apt to be worked to the sides of the road and finally into the gutters. It is then necessary to throw the old material back or apply fresh material, and this of course requires constant attention and considerably increases the cost of

* Abstracted from Bulletin 34 of the Office of Public Roads, Department of Agriculture.

the work. In certain cases the cost of applying sufficient emulsion to lay the dust for a season has been as low as 2 cents per square yard, as compared with the cost of watering in previous seasons of 3 cents per square yard. The cost of applying sand and throwing back material which is carried to the gutters should, however, be added to this in order to obtain the actual cost of maintaining the road in proper condition. Except for a rather faint oily odor, no unpleasant results are obtained from an emulsion of this sort. The principal advantage is its cheapness, which is due to the fact that it is manufactured by the experimenter. It has been found that if too much is applied at one time an undesirable loose scale is formed when the surface dries out. This is undoubtedly due to the soap used, which to some extent destroys the true binding value of the asphaltic base, owing to the presence of fixed alkalies. Light applications at more frequent intervals are therefore to be preferred. As shown by experiments conducted on park roads in Chicago with soap and oil emulsions, a number of factors have to be taken into account when preparing the emulsion. The selection of soaps will be regulated to some extent by the character of the water used, and an oil or oil mixture should be obtained which will properly emulsify with the soap solution. Where the water is hard, a naphtha soap has been found to give the best results.

When for any reason it is inconvenient to install an emulsifying plant, asphaltic-oil emulsions may be purchased which are already prepared in concentrated form. One of these which has been used with good results consists of a heavy Texas residuum emulsified by the addition of ammonia, crude carbolic acid, and creosote, which is incorporated with the oil under the action of heat and agitation. As an emulsion of this sort carries a high percentage of asphaltic binder, it can be diluted considerably before applying. One of these preparations which was examined by the writer was found to contain about 60 per cent of good asphaltic base after most of the volatile constituents had been removed. The quality of the oil employed is, of course, a very important factor in the binding value of the preparation, and therefore in its road-building properties.

When employing this class of asphaltic-oil emulsions it is customary to give the road either one treatment or else two, with a short interval between, of a 15 to 18 per cent solution. The surface is thus thoroughly impregnated with the asphaltic binder, and as the emulsifying agents are more or less volatile, an insoluble and almost waterproof deposit is finally formed upon drying. This binder is not easily removed by rains or traffic, and if weaker solutions containing about 5 per cent of the original emulsion are applied from time to time the dust will be well laid. At the end of a season the road should not only be in better condition than at the beginning, but its wearing quality should be more or less permanently improved, according to the amount of binder which has been retained.

These emulsions can be purchased for about sixteen cents per gallon in concentrated form, and are usually contained in iron drums holding 120 gallons each. In the first treatments 1 gallon of the original emulsions is applied to about every 30 square yards, and for succeeding treatments the same amount is made to cover from 60 to 90 square yards, according to the strength of solution employed. The total cost per square yard during an average season will run from 4 to 6 cents, according to locality and traffic conditions. While this is somewhat higher than the cost of treating with soap emulsions of oil, the results obtained are more permanent, and this fact should be taken into account when comparing the two. Up to the present time the oil emulsions have been used principally upon parkways and suburban roads, as the cost of frequent treatments precludes their use on rural highways.

The next type, the tar emulsions, have up to the present time been more generally used in France, England, and Germany than in our own country. A number of these preparations are sold under trade names and several have been patented. In their simplest form they differ from the oil emulsions only in the fact that coal-tar bitumens are employed in place of the asphaltic bitumens. Coal tar emulsified by means of ammonia and crude carbolic acid might be mentioned as a parallel preparation to the oil emulsion just described. The method of application and results obtained are practically the same as for oil emulsions. At the present time it is impossible to determine the relative value of different oil and tar emulsions. Nearly all of those which have been tried have proved to be effective temporary dust layers, but a number of competitive experiments under similar conditions would be required to determine which is capable of producing the most permanent results at the least expense. At the present time tar emulsions sell for about the same as oil emulsions.

During the past year a tar-preparation competition was held in England in connection with the motor dust trials and spreading-machine competition which have already been mentioned.

Besides the two simple types of emulsions which have so far been considered, many others have been tried, and before leaving the subject it may be well to describe briefly some of them for the purpose of showing how many different materials have been used. It is impossible to classify them satisfactorily owing to their heterogeneous composition. No very systematic arrangement can therefore be followed in describing them.

Glue and bichromate of potash have in some instances been added to an oil or tar emulsion to cause it to harden upon the road surface. Under the action of light this preparation is claimed to become insoluble. Acid-treated cotton-seed oil and tar, emulsified by the action of caustic soda, is another type. A carbolic-acid oil emulsion to which has been added asphalt tar and the residue from glycerin distillation is also on the market. A caustic potash emulsion of coal tar, creosote, pitch, and resin has been patented. There are also a number of English, French, and German preparations which form emulsions with water, but their composition is kept secret by the manufacturers. A Scotch preparation composed of wool grease, soap fats, and potash is sold. A French compound of powdered asphalt and water has also been used. An emulsion of asphalt and creosote with water is another French compound, and there are many others, in some of which wood tar is employed.

A number of patents have been taken out in this country on preparations of various compositions, many of which are interesting because of the fact that waste products from different sources are utilized. One of these patents covers an emulsion of tar or oil to which casein has been added. Another makes use of the water lyes obtained from wood-pulp factories. These water lyes are for the most part waste products; they contain resinous and salt ingredients which form not only binding but more or less hygroscopic compounds upon evaporation.

The fat or grease obtained from wool scourings, when emulsified with deliquescent salt solutions and sometimes creosote, is made the basis of another patent. And still another covers the application of an oil emulsion containing a deliquescent salt and a waste sulphite cellulose liquor produced in the manufacture of paper from wood pulp. The use of waste-molasses solutions, as well as mixtures of saccharine materials and lime, which form adhesive calcium saccharates, has also been suggested.

Nearly all of the materials and preparations described in this bulletin have some desirable qualities, and it is extremely difficult to make a selection among them. In general it may be said that those substances which can be applied in their natural condition have an advantage over the emulsions in the fact that their use is not dependent upon a constant water supply. On the other hand, they are more bulky to store, and transportation charges are proportionately greater than for the special preparations which are sold in a concentrated state. In regard to the emulsions themselves, it would seem that the mechanical emulsion, if it can be properly made and applied, may in some cases prove more desirable than the chemical emulsion, as no non-binding emulsifying agents are required and the original binding material remains for the most part unaltered. Where strong alkalies, such as soda or potash, are used in connection with asphaltic material in particular the high binding bitumens are apt to be split up into substances of lower binding value. This fact has been practically demonstrated by the results obtained from the use of asphaltic oils upon alkali soils, as has been previously noted.

The use of these temporary binders in road construction is advocated by some experimenters. While somewhat better results may be obtained by this means than by the use of water alone, it is very doubtful if they will prove to be economical or of a very lasting character when the small proportion of binding material present in most of these preparations and emulsions is taken into account. In cases, however, where the material approaches the permanent binders in character and quantity of base present, this criticism would not apply. It would seem, however, in any event that the use of a sufficient amount of permanent binder would be preferable when application is to be made during construction, as a better bond between the fragments of road metal is formed than when a water solution of the binder is employed.

A SO-CALLED LOST ART.

IT has been claimed that tempering copper is one of the "lost arts." According to Prof. Hopkins, of the department of chemistry at Amherst College, the idea that copper was tempered in ancient times arises from a thirteenth century misunderstanding of the Greek word *baphé*—a word used by the Græco-Egyptian alchemist writers of the third century. Prof. Hopkins states that Berthelot, the eminent authority on alchemy, has shown that this word tempering may mean coloring cloth, glass, and metals, coloring materials, or the coloring bath. He says that Egyptian alchemy busied itself originally in producing brilliant bronzes on copper and the copper alloys, and that this expression "the tempering of copper" means and always has meant bronzing copper so that it may simulate silver or gold. It would thus appear that copper may never have been tempered, after all. This is a more probable conclusion than that the way to do it has been lost.—Railway and Locomotive Engineering.

THE RHONE 350,000-HORSE-POWER PROJECT.

IT will be remembered that there was brought forward some time ago a project for securing a large amount of current for the city of Paris from a hydraulic plant on the Rhone lying about 250 miles distant. Since that time the authors of the project, Messrs. Blondel, Harlé, and Mahl, have modified it and adopted another method as concerns the electrical operation of the turbine plant and the pole line. Should the project be carried out, and this is within the range of possibility because a current supply for the city is greatly needed, the enterprise will be by far the largest of the kind in Europe. The turbine plant is to be laid out for no less than 350,000 horsepower. Most of the current will be sent over the power line to Paris, but a small part will also serve for the surrounding region of the plant. The radical change lies in discarding the high-tension direct-current system and employing the alternating three-phase current. Many objections had been made by leading engineers to the old project. It had the disadvantage of using a system which although it works with success in the limited number of plants where it is used, such as the power plants from Moutiers to Lyons and St. Maurice to Lausanne, was not widely adopted in different countries such as we find for the three-phase method of operating. Accordingly the latter has been considered better on the whole, and the plans were entirely modified so as to use the alternating system.

The hydraulic work for the 350,000-horse-power turbine plant will, of course, be a great undertaking. A site has been selected on the Rhone about 30 miles from where it flows out of Lake Leman and lying below the important Swiss turbine plant at Chèvres which we have already illustrated.

The present plant will be located (according to the project) at Genissat, across the French frontier, where the Rhone flows in a deep gorge. Owing to this formation of the banks, the water can be backed up for a considerable distance so as to form a large basin, which will be valuable as a reserve supply. The dam will have a slope at the front of some 40 degrees, but at the rear side next the basin it will be practically vertical. The wall will be faced with a continuous sheet steel surface formed by the electric welding process, so that there will be an entire absence of fissures. Such a facing will give an excellent protection for the dam. The latter will be 250 feet high and about the same width at the base. At the water side it is protected first by a masonry wall 60 feet high and 30 feet wide built along the base of the dam. Farther in the rear is a masonry dike of triangular section and somewhat larger than the wall. In order to build the dam upon dry ground there will be erected a temporary dam completely across the gorge so as to retain all the water, and an outlet for the latter is provided by cutting a number of tunnels in the rock so as to lead the water to a point below the construction work. The temporary dam and tunnels will be suppressed after the hydraulic work has been finished. From the dam the water will be taken to the turbine house which lies not far below the present construction, by using a flume of 350 feet width and 25 feet depth. Arrangements are made for taking off twenty-five penstocks from the flume, each penstock having a separate water-gate for shutting it off. Each of the penstocks, of sheet steel, has a capacity of 700 cubic feet per second.

The turbine plant located below the dam will undoubtedly be the largest in the world, both as to the size of the building, about 1,000 feet in length, and the number and size of the wheels. The plant is laid out from the start to take twenty-four turbines of about 15,000 horse-power each, or as already stated, 350,000 horse-power in round numbers. Such wheels are to run at a speed of 250 R. P. M., and each one coupled direct to a three-phase alternator. These latter will give current of 12,000 volts. Situated near the plant will be a separate building in order to contain the transformers and the various apparatus for the power line. Here will be used banks of transformers which will raise the current to 120,000 volts for use on the power line. For the main line running for 250 miles to Paris there will be two distinct conductors upon the poles, each being made up of six cables connected in two sections of three cables each, using a 20-millimeter section cable.

AN APPARATUS FOR DESTROYING MOTHS.

USING THE ELECTRIC LIGHT AS A TRAP.

DURING the past few years the larvæ of the "nun" moth have committed very extensive ravages in the forests of Germany and Central Europe, devastating thousands of acres and necessitating the hasty cutting of millions of cubic feet of timber. Of the methods which have been tried in the warfare against the insects the most successful was the one adopted last summer by the city of Zittau, in Saxony, which possesses extensive municipal forests. This method is based on the attraction which lights possess for moths, and on the observation that the nun moths were most active and most strongly attracted between the hours of 10 P. M. and 1 A. M., when the direction of their flight was found to be greatly influenced by the passing of brightly lighted railway trains, the glow of the illuminated city, etc.

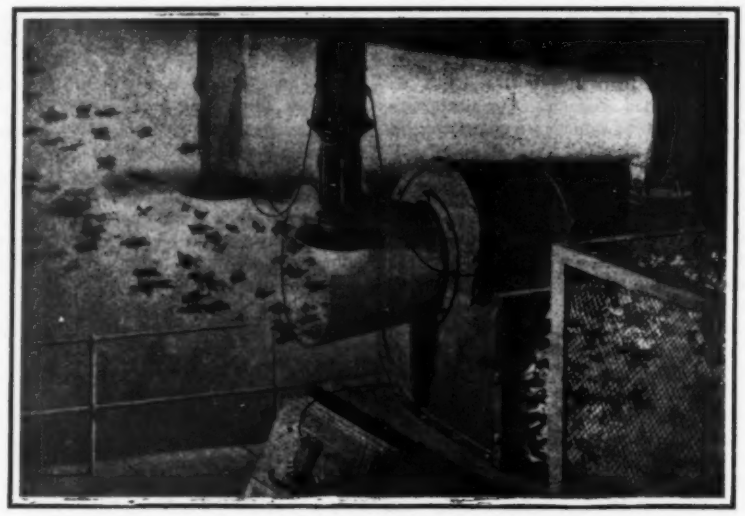
Experiments with various sources of light proved that a very intense light was required in order to exert a well-marked effect, and that electric lights attracted the moths far more powerfully than wood fires, gas lamps, or acetylene or magnesium lights.

The moths deserted gas lamps for electric lights in their vicinity. The bluish light of the quartz mercury vapor lamp proved especially attractive.

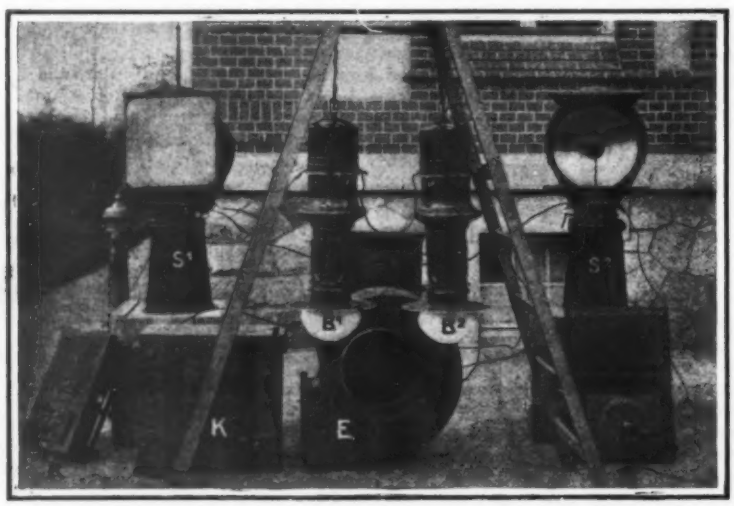
The problem, then, was to lure the moths from the forest by powerful lights and to devise means of destroying them in great numbers. First, the globes were removed from most of the street arc lamps, with the result that the moths flew in vast swarms from the forest, a few miles distant, to the city, and many of them were killed by contact with the white hot carbons. Many escaped, however, and vastly better results were obtained by the following method, which was used in connection with the preceding.

At 11 o'clock all the street lamps were extinguished and powerful beams of light were thrown by searchlights of 40 amperes capacity on that part of the forest which was most seriously infested by the insects. Each of these searchlights was flanked by two inclosed flaming arc lamps which served to hold the moths which had been attracted by the searchlight. These lamps also illuminated the inlet of a blower, into which the insects were drawn and from which they were blown with such violence against a wire gauze screen of about 4/10 inch mesh that they were killed or crippled by the impact. The single gauze screen was ultimately replaced by a collecting box, having three sides of iron wire netting and one open side, which was placed close in front of the outlet of the blower. Two searchlights were also used at each station. When so many moths had been collected that the air blast was obstructed, the box was removed and emptied. The blower, driven by a direct-coupled electric motor, made about 1,200 revolutions and delivered about 2,800 cubic feet of air per minute. Searchlights and blowers were placed on the tower of the city hall and the roofs of three other buildings.

The operation of the apparatus was very interesting. Soon after the lights were turned on the moths began to arrive, singly and in small clusters, but their numbers rapidly increased to thousands and tens of thousands, and the apparatus, the operators, and the roof were covered with their mangled bodies. Meanwhile men armed with brooms were busily engaged in killing the moths that settled on the roof, etc., and sweeping them into bags and boxes. The catch, however, was not always so great as this. On some nights very few moths were caught, while on others as many as 400,000, weighing 200 pounds, were destroyed at one station. The variation was due both to biological and to meteorological causes. Cold weather, bright moonlight, and contrary winds diminished the influx of moths, but the catch was little affected by gentle rain and it was apparently increased by the sultriness preceding thunder storms. As a rule, very few moths were caught at temperatures lower than 50 deg. F., although especially large numbers were destroyed on some calm and cloudy nights at temperatures below 60 deg. F.



THE MOTH-DESTROYING APPARATUS IN OPERATION.



AN APPARATUS FOR DESTROYING MOTHS.

S^1, S^2. Searchlights. B^1, B^2. Arc lamps. E. Blowers. K. Collecting box.

In contradiction of previous observations, it was found that the moths attracted by the lights were not almost exclusively males. The proportion of females often exceeded 40 per cent—a point of capital importance in this war of extermination.

Excellent results were obtained on a smaller scale with a portable apparatus including an acetylene light, which was set up at various points in the forest. Next summer, if the plague of moths continues, the war will be resumed still more vigorously.—Umschau.

INTERESTING TECHNICAL HINTS ON PORCELAIN.

AT the thirty-second general meeting of the "Verband Keramische Gewerbe in Deutschland" (Association of the Ceramic Industries in Germany) held on March 26th, 1909, a highly interesting address on the "Technical Side of Porcelain" was delivered by Privy Councillor Dr. Heinecke, director of the Royal Porcelain Works at Berlin. The speaker first called attention to the fact that the preceding year marked the lapse of 200 years since Böttger discovered the method of making red porcelain and that next year we could celebrate the 200th jubilee of the European white porcelain industry. It was indeed a remarkable feat that Böttger, following the method he adopted, had ever succeeded in producing a useful porcelain. He added lime to the kaolin as a flux, and when we consider that adding equivalent quantities of marble, only about one-fifth of the addition of feldspar is needed, that it is therefore necessary to distribute 5 per cent of marble uniformly throughout the mass, it is remarkable that Böttger was successful. The speaker dwelt further on the constitution of the porcelain mass, which consists of clay substance, flux, and quartz. The clay substance is the ingredient that makes the mass plastic and fire-resistant; the fluxes, among which feldspar occupied the foremost place, effect the cementing together of the remaining ingredients, and the quartz, where it is not present in such finely divided condition as to act likewise, at suitable temperature, as a flux, has the effect of a filling substance, counteracting the shrinking of the clay substance and serves as a reducing agent.

The fluxes, i. e., the melting substances, must be insoluble in water. In place of feldspar, of course, other fusible substances may be employed. Dr. Heinecke attempted to use glasses free from alumina, but these experiments all resulted in failure, because the finely ground glasses were too actively soluble in water and set free so much alkali, that when stored the mass would run apart. Better results were obtained by the employment of glasses containing alumina. Two glasses with the composition of K_2O . 2CaO . Al_2O_3 . $18SiO_2$ and K_2O . 3CaO . Al_2O_3 . $24SiO_2$ were used, with which several masses were made up. These porcelains proved especially suited for decoration. A porcelain of the composition R_2O . $3Al_2O_3$. 18SiO served, burned at SK 10 to 11, for decoration with crystal glazing.

The speaker then made more particular reference to the production of crystal glazes, in which he used only titanic acid as the crystal-forming medium, and described the method he employed in flowing the glaze on the porcelain. Another porcelain, of the following composition, R_2O . 2.5 . Al_2O_3 . 15SiO produced, when burned at SK8, a very pure, translucent ware, very well adapted for underglaze painting, using the coloring substances employed in the earthenware industry for the production of underglaze colors. The coloring substances are applied mixed with porcelain mass and covered with a suitable leadless glaze. The speaker then turned his attention to the baking process. With regard to these statements reference may be made to the work "On the Firing of Porcelain," compiled by the speaker.

A porcelain with a composition of R_2O . $3Al_2O_3$. $21SiO_2$ can bear, fired at SK 9-10, aluminiferous lead glazes melted at the fusing point of silver, free from cracks. This serves as the foundation for between-glaze painting, the various styles of which were explained with the aid of sample specimens.

To obtain the brilliancy of the colors, such as they display on stoneware containing lime, a glass, rich in lime, is prepared. In the experiments made it was shown that the brilliant colors only appear when there is much alkali and lead in the glasses. On to such a mass, which, when burned at SK12, is very translucent, alkali lead-glasses free from boric acid and alumina can be fused with great brilliancy.

Imitations of the red Böttger porcelain were produced by the lecturer with ground Cadinen clay mixed with "Abraum" earth from Halle and Helmstedt clay, also with Rathenow clay.

He then essayed to use the Rathenow clay as a flux for porcelain masses. The masses thus produced are

more homogeneous and harder than feldspar masses, and can be readily poured. A body of this mass showed 48 g. grinding loss, whereas ordinary porcelain, under the same conditions, showed 74 g.

By the addition of porcelain fragments to the mass, the shrinkage may be reduced to 8½ per cent. If the addition of fragments is increased still more, the shrinkage is again augmented. This phenomenon is readily explained by the fact that too liberal an addition of fragments makes the mass loose in texture, and the increased shrinkage in firing is easily understood.

GYROSCOPIC BALANCING OF AEROPLANES.

SUGGESTED METHODS OF MAINTAINING EQUILIBRIUM.

BY LUCIEN FOURNIER.

M. LOUIS MARMONIER, of Lyons, France, has devised a gyroscopic pendulum by the automatic action of which, it is claimed, the steadiness of aeroplanes may be assured. Attempts have already been made to secure this result with the aid of the pendulum alone. The pendulum is unsatisfactory because, although its weight tends to keep it in a vertical position, it does not, after being disturbed, definitely resume that position until after it has made a series of oscillations, the number of which increases with the length and mass of the pendulum and the violence of the disturbance. Furthermore, the centrifugal force of a heavy pendulum would be a source of great danger in turning. It is true that the number and extent of the oscillations can be diminished by springs and other compensatory devices, but this solution of the problem is contrary to the principle of an automatic balancer, which should be entirely independent of the apparatus which it controls.

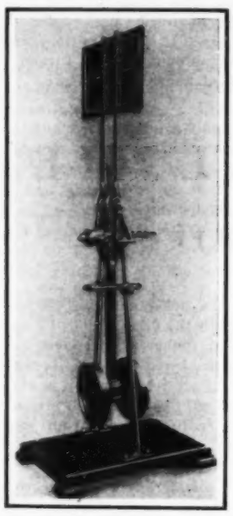


FIG. 1.—MARMONIER'S GYROSCOPE PENDULUM FOR BALANCING AEROPLANES.

The simple gyroscope has also been proposed as a balancer but, so far as I know, no experiments have been made with it. A small gyroscope would not be able to govern an aeroplane, even by acting upon special balancing organs, such as the adjustable or deformable upper planes (*plans de gauchissement*) with which some aeroplanes are provided. Although the gyroscope would offer resistance to any attempt to change the direction of its axis of rotation, it would, nevertheless, be subject to the pressure of the surrounding medium and to the resistance of the organs which it is required to control. Hence it would change its direction by insensible degrees and would carry the aeroplane with it.

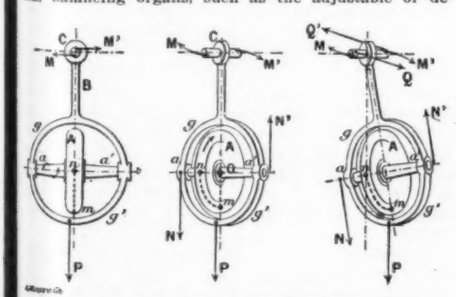


FIG. 2.—THEORY OF THE GYROSCOPE PENDULUM.

On the other hand, a very heavy gyroscope could not be used on an aeroplane because of its weight and the force required to drive it with the necessary speed, and especially because its inertia would interfere with the operations of ascending, descending, and steering.

Although neither the gyroscope nor the pendulum alone will accomplish the object desired, Marmonier has endeavored to insure the lateral stability of an aeroplane by means of the gyroscopic pendulum, which combines the advantages of both, and is free from their principal defects.

In the Marmonier apparatus (Fig. 1) two flywheels are mounted on a short horizontal shaft which is attached, at its middle point, to the lower end of a vertical rod. The whole forms a pendulum which can oscillate only in the plane containing the axis of the wheels and perpendicular to their forces. The pendulum rod is prolonged above its axis of suspension and its upper end carries a vane, parallel to the faces of the wheels, the function of which will be explained later. The wheels, driven by the aeroplane motor, rotate rapidly in the same direction. The axis of the gyroscopic wheels and the plane of oscillation of the pendulum are perpendicular to the longitudinal axis and direction of flight of the aeroplane.

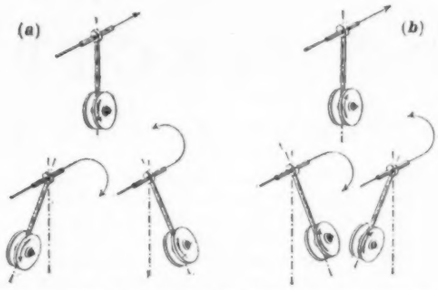


FIG. 3.—EFFECT OF DIRECTION OF ROTATION AND CHANGE OF COURSE ON INCLINATION OF PENDULUM.

A gyroscopic pendulum of this construction, projected through space in a straight line perpendicular to its plane of oscillation, will remain vertical, no matter what the direction of rotation of the wheels, the velocity of projection, or the violence of the lateral displacements to which it is subjected, as the weight, the passive inertia and the gyroscopic action of the heavy and swiftly rotating wheels conspire to oppose any departure of the rod from the vertical. The pendulum will swing only under the influence of angular displacement.

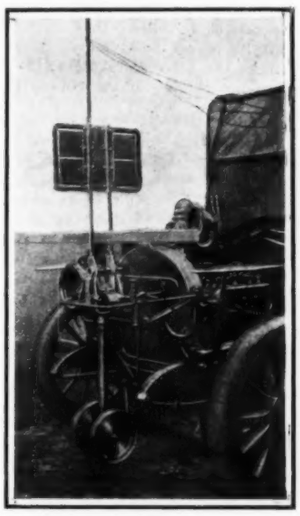


FIG. 5.—THE GYROSCOPE PENDULUM ATTACHED TO AN AUTOMOBILE FOR TESTING.

When the aeroplane changes its course the apparatus is rotated about its vertical axis, coincident with the rod of the pendulum, the effect being that of a couple of forces applied to the ends of the horizontal axis of suspension. These forces are denoted by the letters $M\,M'$ in the left-hand diagram of Fig. 2, in which M', directed toward the right, is applied behind,

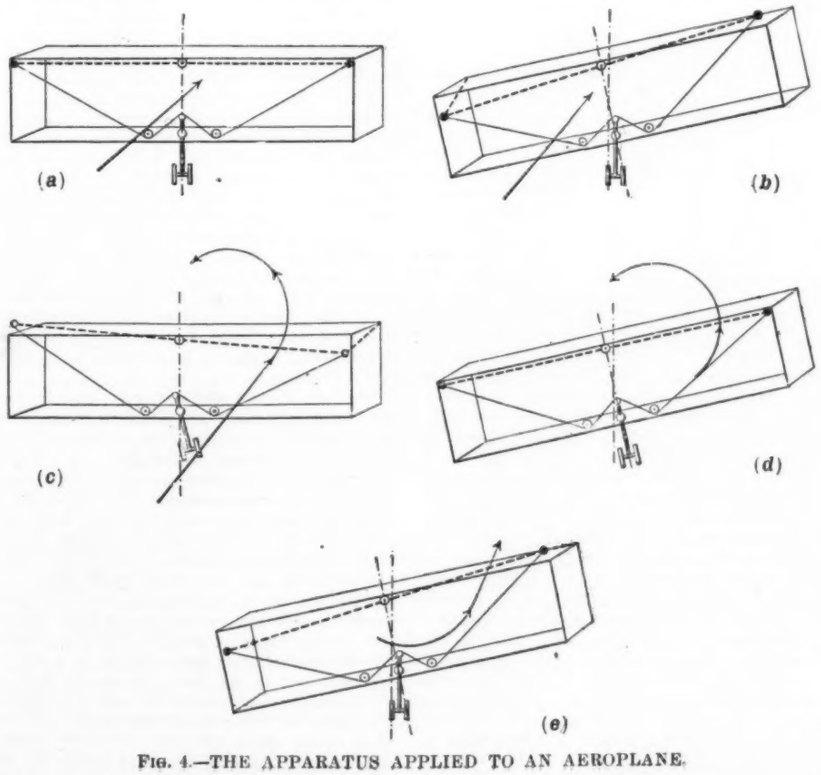


FIG. 4.—THE APPARATUS APPLIED TO AN AEROPLANE.

and *M*, directed toward the left, is applied in front of the plane of the paper, which represents the plane of oscillation. The two flywheels are represented by a single wheel, the front part of the rim being supposed to move upward, as indicated by the arrow. By the laws of gyroscopic action, this couple acting round a vertical axis (the pendulum rod), in conjunction with this rotation round a horizontal axis (the shaft of the flywheel), will generate a couple (*N N'*) acting round a third axis (the horizontal axis of suspension of the pendulum) at right angles to both of the axes above mentioned. This couple will swing the pendulum to the right, as illustrated in the right-hand diagram (Fig. 2). The inclination of the pendulum will increase with the magnitude of the original disturbing couple *M M'*. The inclination will also be inversely proportional to the length of the pendulum and will be a maximum if this length is zero, in which case the apparatus becomes a simple gyroscope. When the disturbing couple *M M'* ceases to act, the pendulum will return to the vertical position.

The direction in which the pendulum inclines will be reversed by reversing either the rotation of the flywheel or the disturbing couple *M M'*, the direction of which couple depends on the direction in which the aeroplane turns in changing its course. From these considerations it follows that if the wheel rotates so that its lowest point moves forward, or in the direction of the aeroplane's flight, the pendulum will swing to the outside of the curved path, when the aeroplane is turned in either direction (Fig. 3 *a*), and that the pendulum will swing to the inside of the curve, in either case, if the rotation of the flywheel is reversed (Fig. 3 *b*). The latter arrangement is the one adapted for aeroplanes, yet the pendulum will actually swing to the outside of the curve, in obedience to the centrifugal force developed in turning, which would cause a simple pendulum to assume a nearly horizontal position, and which is only partially compensated by the gyroscopic action described above. The amount of compensation and, consequently, the inclination of the pendulum, depend upon the length of the pendulum and the weight, diameter, and velocity of the flywheels.

The manner in which the gyroscopic pendulum acts upon the deformable upper plane of the aeroplane, by means of cords and pulleys, is indicated in Fig. 4. When the aeroplane is steered to the left (for example) the pendulum swings to the right and depresses the right side of the plane (Fig. 4 *c*). The reaction of the air to this deformation promptly raises the right side of the vehicle until both surfaces are perpendicular to the inclined pendulum, the upper plane straightening and resuming its normal relative position (Fig. 4 *d*). In this inclined position the vehicle makes the turn in favorable conditions as the air presses inward on the inclined surfaces and prevents "skidding." When the turn is completed and the course again straight, both the gyroscopic action and the centrifugal force cease, and the pendulum, under the influence of gravity, becomes vertical. In this position it is inclined to the left with respect to the tilted aeroplane (Fig. 4 *c*), and the effect is to depress the left side of the upper plane and to right the vehicle by a reversal of the process by which it was tilted.

The aeroplane is quickly righted in the same manner if it is tilted by any cause when pursuing a straight course (Fig. 4 *b* and *a*). In this case no gyroscopic action is produced and the apparatus acts simply as a pendulum.

The function of the vane attached to the top of the pendulum rod is to vary the inclination of the pendulum, and therefore that of the aeroplane, according to the direction and force of the wind. The vane, blown to leeward, forces the pendulum to windward, and by a process similar to that illustrated in Fig. 4 *c* and *d*, tilts the aeroplane to leeward and opposes its lower surfaces to the wind—the most advantageous position. In turning in a wind, the vane aids the pendulum in placing the aeroplane in the best position.

The Marmonier apparatus, which weighs about 22 pounds, has been tested by attaching it to the front of an automobile by means of brackets and springs, so that it was protected from shock. The flywheels were driven by the motor of the car by means of a friction wheel. The aeroplane was represented by a transverse bar of wood, marked "aeroplane" in the photograph (Fig. 5). The positions assumed by this bar when the automobile was turned confirmed the theory explained above.—La Nature.

THE COST OF ELECTRICAL HEAT.*

OUR PRESENT KNOWLEDGE OF THE SUBJECT.

THE processes to which electrically generated heat can be applied in this country are limited to those in which its superiority in temperature control and effectiveness of application render it either unique in some particular or more efficient as regards cost than heat obtained directly from fuel, whether solid, liquid, or gaseous. In localities, however, where large quantities of cheaply developed water power or other sources of cheap power are available, the conditions are now such that the commercial utilization of electric heat may afford the only means of development of the natural resources of those localities. Very little consideration serves to show, moreover, that the number of uses to which it can be put, even in this country, where fuel is so cheap, are not fully realized.

Theoretically the horse-power-hour is equivalent to about 2,545 B. T. U., and if the assumption be made that the load-factor necessary for the best conditions for power generation can be attained, one may expect, on a reasonably large scale, to obtain this quantity of heat for a consumption of 1 pound of high-class coal, the calorific value of which may be taken as 15,000 B. T. U., with an efficiency of conversion therefore of 2,545/15,000, or, in round figures, 17 per cent. Remarkable and difficult, though not impossible of attainment, as this efficiency is, the conclusion leaps to the eyes that, when the capital costs involved are considered, it is only in cases where the losses in heat in the direct furnaces are extremely high, or where exceptional conditions of temperature or of control are necessary to the process using the heat, that fuel-generated electrical heat can be considered a commercial proposition. That such conditions exist, however, is proved by the increasing use of the Kjellin, Héroult, Stassano, and other electric furnaces for a variety of purposes, and it cannot be questioned that as investigators widen their field of experiment further uses will be found. As regards ease of control and in cases where very high temperatures are not required, the gas furnace must, however, continue a formidable rival to the electric furnace.

Our knowledge of the subject has now so far advanced that installations for the utilization of electric heat can be developed on sound engineering lines, and with no element of risk of technical failure, so that, given the condition that coal is dear and water power, or power from waste gas, relatively cheap, in any locality electrical heat is, *cæteris paribus*, the only commercially possible proposition. It is impossible to generalize, as each case must be treated on its own merits, every influencing circumstance, such as the use to which the heat is to be put, the cost in the locality of raw material for the process in contemplation, and the situation of the power with regard to the markets, being given its own place in the general scheme. But it is of interest to bear in mind that, if we assume equal efficiency of application (an assumption generally greatly in favor of fuel), we can arrive at a basis of comparison. The "electrical horse-power-year," which cumbrously expresses a quantity of work, is equivalent to $2,545 \times 24 \times 365 = 22,300,000$ B. T. U. (nearly). If we take the thermal value of 1 pound of coal, as before, as 15,000 B. T. U., we get the coal equivalent of the horse-power-year, $22.3 \times 1,000,000/15,000 = 1,485$ pounds (nearly), or 0.67 ton (2,240 pounds). Thus, if the money value of the horse-power-year obtained from water power, waste gas, or other cheap sources, is in any locality less than that of 0.67 ton of coal of a thermal value of 15,000 B. T. U., plus the cost of making the heat in it available, then, other things being equal, it is more economical to make use of electric heat. As has been remarked, however, the greater efficiency of application of electric heat makes this figure in general greatly favorable to coal. As illustrating this point the following is of interest.

The electrical work done in refining one ton of steel of the crucible class appears to be from 0.13 to 0.17 E. H. P.-years, say, an average of 0.15 or $3.36 \times 1,000,000$ B. T. U. On the other hand, in crucible steel making by the ordinary method about three tons of coke, which may have a thermal value of 14,000 B. T. U. per pound, are required, or a total $3 \times 2,240 \times 14,000 = 94.2$ million B. T. U., or 28 times as much heat per ton as is absorbed by the same process carried out electrically. In other words, if the heat usefully applied in the electric furnace be taken as 80 per cent of that applied (it is difficult at present to find figures on the point), then the heat wasted in the crucible process must be about 97 per cent of that supplied, and the lower the assumed efficiency of the electrical furnace, the greater the loss in the ordinary process works out. Even under English conditions this astonishing heat saving insures the future of the electrical method. It is said that in regenerative crucible furnaces the fuel consumption is reduced to 1 ton, but even so, the heat wasted amounts to 91 per cent of the whole, on the same basis. The case shows what has already been done in the matter of heat economy by electrical means, and indicates what may be expected in the future in other directions.

The cost of heat obtained from burning coal, on the theoretical basis, varies in this country according to the cost of the coal and its thermal value from 8 cents to 14 cents per million B. T. U. The lowest published cost of generating energy is somewhat under 1 cent per kilowatt-hour, and this is equivalent to about $3 per million B. T. U.; on the large scale about one-half of this might be represented by fuel, or say, $1.50 per million B. T. U., or 13 to 26 times the cost of the same heat given to the boiler by burning the fuel in its furnaces. It has to be borne in mind, however, that figures such as have been quoted are obtained from plants not primarily designed to deliver electrical heat and working on a load factor of from 15 to 20 per cent, whereas the first aim in the arrangement of electric furnaces is to insure that the source of power shall work at its full capacity at all times, which will very materially reduce this cost, in many cases so far as to enable the electric furnace with its vastly superior efficiency to compete successfully with the directly burnt fuel. In considering the cost of fuel-generated electrical heat, it has also to be remembered that the reiterated statement that the cost of electrical supply is entirely a matter of capital is only to a limited extent true. There is a certain irreducible minimum representing fuel cost, and the better the capital involved is utilized the more closely does the total approximate to this minimum and the larger does the proportion of cost due to fuel become. It is thus unlikely that a large power scheme, handicapped with distribution costs, could successfully compete with a relatively insignificant heat plant working on a 100 per cent load factor.

In localities where blast-furnace gas is available, the conditions are still more favorable to electric heat. A blast-furnace is said by Gruber to produce gas in such quantity that, after the requirements of the works have been met, about 23.5 horse-power per ton of pig produced in 24 hours is available externally, the thermal value of the gas being taken by him as about 101 B. T. U. per cubic foot. This figure is probably too high, as an average, and it is safer to figure on 70 B. T. U. per cubic foot, equivalent to 16.5 horse-power per ton produced in 24 hours, or for a furnace producing 100 tons, 1,650 horse-power. From this, taking the efficiency of the electric generators as 90 per cent, we can do electrical work at the rate of nearly 1,100 kilowatts, or in the 24 hours 26,400 kilowatt-hours = 90 million B. T. U., the cost of this heat being the cost of making it available, the fuel being obtained without cost. Now, if the capital cost of making this power available be taken as $100 per kilowatt, a reasonable figure, and the annual capital charges 12 per cent on this sum—leaving wages out of consideration as being assumed the same in the two cases—the cost for the 1,100 kilowatts for the day would be $35.75, or about 3.33 cents per kilowatt per day, which is equivalent to 36.4 cents per million B. T. U., or three times the average cost of the theoretical heat to be obtained from burning coal.

In localities where cheap water power is available and a demand for heat exists, or can be created, the conditions are most favorable of all. But it is important to recognize the fact, so often overlooked, that water power is not necessarily cheaper than other sources of power, whether it is so or not depending on the cost of making a regular output available, this cost varying enormously in different water courses. Thus, for instance, in Scandinavia the cost of the "electrical horse-power-year" varies, according to circumstances, from $8.25 to about $55, or from 36.8 cents to $2.46 per million B. T. U. Equally low costs have been attained in Italy and in Switzerland, but in America the average cost appears to be materially higher than in Europe. Obviously, however, from what has been said it is clear that the superior efficiency of the electric furnace should render electric power under conditions making in any way possible the lower of the above-mentioned figures, or any-

* Electrical Engineering.

thing approaching it, a very much cheaper source of heat than any other. Naturally, the cheaper water powers have been, in the majority of cases, long ago equipped for various purposes, but there still exist large undeveloped Scandinavian falls which have been thoroughly investigated by competent engineers and shown capable of producing power at an exceptionally low rate.

Metallurgical uses of electrical heat are increasing year by year, and in them doubtless the largest developments will take place, but there would appear to be a large field for its application in those cases where a closed chamber contains the object to be heated, the heat being transmitted from without inward through the walls of the chamber, such as pottery ovens, and kilns, bakery ovens, and so on. It has been calculated, for instance, that in certain types of pottery kilns in regular use, the total mass of material actually heated is about 100 times that of the mass of the material that is the object of the heating, a large part of the body of the kiln attaining a much higher temperature than its contents.

In these cases it is, of course, essential that the flame and products of combustion should be entirely isolated from the object to be heated, and electrical heat, chemically clean, capable of accurate control, and of application exactly where it is wanted, would seem to fill all the requirements of the case, even though the cost of the electric power employed be not the lowest possible.

THE NEW "MONO-TELEPHONE."

A HIGHLY SENSITIVE RECEIVER.

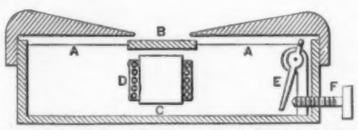
A NEW form of mono-telephone has been devised by M. Abraham, of Paris, and it was described at a recent meeting of the Electricians' Society.

The mono-telephone is an apparatus resembling a telephone receiver and it has a vibrating armature which, instead of being a thin iron diaphragm fixed in the support as we find in the usual telephones, is formed on the contrary of a large steel disk carried by three points of a nodal line, and it thus acts as a veritable resonator. An electro-magnet acts upon the central part of the disk, and when an alternating current is sent into the magnet, the disk sets up a vibration. The intensity of the vibrations depends on the period of the alternating current. If this period is very near that of the characteristic vibration of the disk, the latter gives a good resonance and the amplitude of the vibrations becomes considerable. We may almost say that the apparatus does not respond except for a single vibration period of the current, and this property is quite important for a great number of experiments. M. Mercadier has made a good application of this resonance in his system of multiplex telegraphy on the vibratory system, in which the vibrations are sifted out by means of mono-telephones which serve the purpose of resonators. Wireless telegraphy can also use the mono-telephone receivers, provided there is designed a type which is sensitive enough. In fact, M. Blondel proposed their use some years ago. The transmission can be made by rhythmic emissions, making the signals to succeed at equal intervals and of about one-hundredth second, so as to secure a vibratory effect. At the distant end we use a mono-telephone receiver which is operated by any form of coherer or detector. The telephone signals are taken thus by ear. (However, the mono-telephone can be also made to operate a relay.) The advantage of this combination is evident, and we now have an acoustic method of tuning which is added to the electric turning or syntonizing methods so that we have an increased security for messages. However, this cannot be carried out if we do not dispose of a very high power as in the Cliffden or Glace Bay stations, which use 500 horse-power; it is scarcely possible to increase the frequency of the signals without reducing the power of each signal in proportion, and thus the distance for signaling is necessarily reduced. This method could be made possible by the use of an improved device which would be much more sensitive for its characteristic note than the ordinary telephone receivers, and this is not impossible. Thus the Blondel method would be capable of practical use, for the increase of sensitiveness would make us gain what the small power of the waves had lost. At the same time the signaling would be much easier from the fact of using low tensions.

The new apparatus designed by M. Abraham is a step toward this end. It is an ordinary telephone of any suitable form which has been modified so as to give an adjustable mono-telephone. The apparatus is constructed in a very simple form (see diagram). Some parts of the usual telephone are preserved, such as the box, the earpiece, the magnet. The iron diaphragm is removed and another armature is formed of an iron plate which just covers the electromagnet. This armature is carried by two flat strips or wires of a strong metal which are stretched parallel, and it is thus kept at the right distance from the poles. Such a system of suspension has an excellent elasticity, and the vibrations proper to the armature are clearly musical. We can vary the characteristic vibration of the instrument at will and between wide limits by acting on the tension of the wires by means of a lever and screw.

The author compared the sensitiveness of this form of receiver with that of other telephones of the same type. Both types had a sensitiveness of the same order except when they were used on rhythmic currents at unison with the proper vibration of the instrument, and the new apparatus then had a much greater sensitiveness than the usual telephone. In this receiver the functions of the telephone diaphragm are better separated than in the common telephone, as here we have distinct parts which play the part of the armature and of the elastic spring. The armature can be made very rigid and the spring can be given but an insignificant mass. The result is that, if desired, the proper vibration can be practically free from harmonics.

The undulatory currents which the instrument is thus able to sift out are not limited to a single octave. These currents can therefore correspond to notes of any height in the scale, provided that they in turn do not contain harmonics. But we can easily produce these undulatory currents without harmonics. Thus it is seen that we can produce an inexpensive device whose characteristic frequency can be regulated to any desired point and which has a much greater sensitiveness than the best telephone receivers. It is to be hoped that the new mono-telephone will aid in solving the present problem.



A, wire; B, armature; C D, electromagnet; E F, wire tightener.

THE NEW "MONO-TELEPHONE."

ELECTRICAL VIEW OF MATTER.*

By SIR OLIVER LODGE.

OUR present attempt to see into the structure of the atom is by resolving it into an assemblage of electric charges, most of them of minute specified size, and all of one sign, called electrons; though the complete aggregate must possess also an equal charge of opposite sign, so as on the whole to be neutral, except in so far as an outstanding unit or two may convert it into a monad or a dyad ion. How the negative charges are arranged, and what form the equal positive charge or charges may take, are problems still awaiting solution, to complete this part of the theory of matter.

Comparatively early speculation and calculation on this subject are contained in a remarkable paper by Lord Kelvin, published in the Philosophical Magazine, 1901, under the title "Æpinus Atomized." It is reproduced in the volume of Baltimore Lectures as Appendix E. To him also we owe the first attempt to work out the statics of an atom according to a simple conception whose major consequences can be traced with comparative ease, viz., that of a spherical portion of uniform positive electricity in which minute negative charges are sown like specks being attracted toward the center of the sphere according to the law of direct distance, and repelling each other according to the inverse square law.

Various interesting groupings can be easily calculated as stable patterns; and they tend to become more stable if they revolve regularly round the center or if sustained by a central group or particle. But although the distribution and properties of such groups are profoundly suggestive and interesting, the behavior of atoms consisting of a mass of positive electricity with even a single electron inside them became instructive in the hands of Lord Kelvin.

Thus equal and similar neutral atoms of this kind (the positive charge equaling the negative in quantity, not in size) would exert no force on each other, till they touched and partially interpenetrated; then they would attract and cohere. But they would not presumably interfere with or damage each other, and when separated would be as neutral as before. But if one sphere were distinctly smaller than the other, though equally charged, the neutrality would not continue. The more concentrated would be the more powerful. Pressed together the electron at the center of the larger one would be much displaced, and under certain conditions would actually be absorbed and retained by the smaller sphere, so as to be carried away by it when they separated again. Thus, after the collision, one of the atoms would have become positive, by losing its negative electron; and the other would be negative, by having acquired one too many. The likeness exhibited by the phenomena of such a presentation or model to contact electricity, and to the strong electrification produced between insulators when pressed or rubbed together, is obvious.

A sphere of positive without negative nucleus, brought near or in contact with an equal sphere possessing one, would not be able to rob it; nor could a big one ever take the nucleus from a smaller one. But one which was even a little smaller, any size less than 0.89 the diameter of the bigger one, would, if it approached close enough, pull the electron completely out and assimilate it itself.

It is confessedly unlikely that any atom should have only one electron; but that which it is fairly easy (not too easy) to calculate for this simple case would happen in modified fashion in more complex cases, when the electrons were more numerous; and a vast number of possibilities suggest themselves, such as with ingenuity can be made to account for a great variety of the fundamental facts of chemistry. Ingenuity such as is needed for this difficult work, which at present is only in its infancy, has been conspicuously displayed in various well-known writings of Prof. J. J. Thomson.

Meanwhile to return to Lord Kelvin: Where there are more than one or two electrons in the atom, constituted as supposed above, they distribute themselves in stable form as follows:

Three form a plane equilateral triangle.

Four are at the corners of a regular tetrahedron.

Five may be stable if four are in a plane at the corners of a square and one centrally perpendicular to the plane of the square; but they are more certainly stable if three are in a plane, and two are on its central perpendicular, one on each side.

Six are stable at the corners of a regular octahedron; they are also possibly stable in a plane if one is at the center and five at the corners of a pentagon.

Eight can be at the corners of a cube, but with insecure stability, unless there are some at the center, too.

Twenty, at the corners of a regular dodecahedron, would either have to be constrained to lie on a spherical surface or else would have to be well sustained by repulsive forces from the interior.

The calculation for space-distribution becomes complicated, and most attention has been paid to distribution in a plane; wherein the criterion for stability, as depending either on central repulsion or on centrifugal force due to regular rotation, has been admirably worked out by J. J. Thomson in a methodical and very instructive way. A typically instructive and simple case is that of four electrons revolving round the center. So long as they are revolving above a certain angular speed they are stable when at the corners of a square; but if the speed falls below a critical value, this grouping becomes unstable and they fall, with a convulsion and emission of energy, into a statical position of equilibrium at the corners of a tetrahedron. It is in a direction typified by this simple example that some of us are looking for an explanation of spontaneous radioactivity.

* Journal of the Society of Chemical Industry.

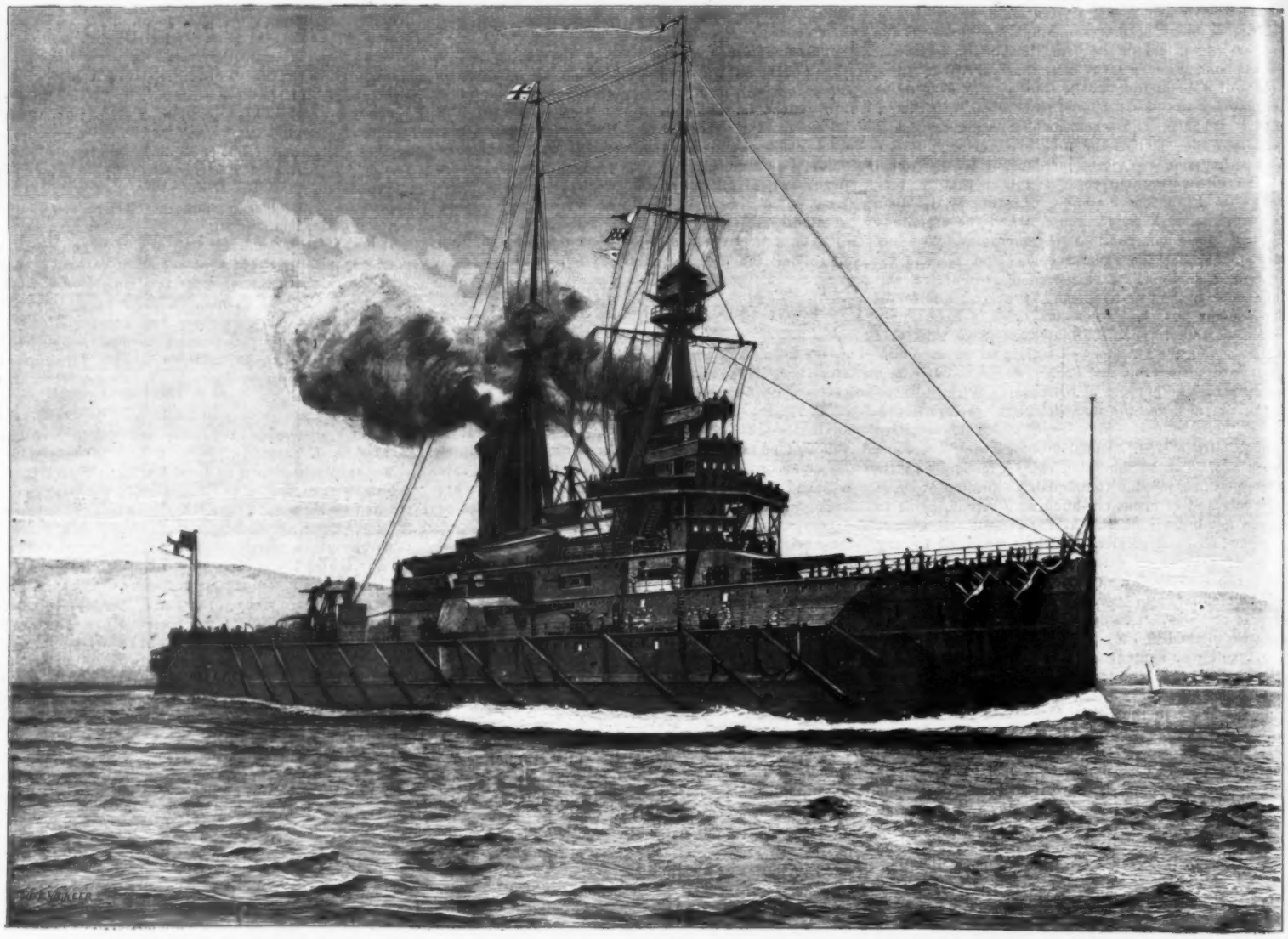
The analysis of alloys of iron and silicon, by the usual methods, is difficult and tedious, as it is necessary to pulverize the metal and expose it for a long time to the action of fused alkalies. M. Nicolardot has discovered in the commercial sulphur chloride a very valuable auxiliary, the analysis of iron, as this compound promptly and energetically attracts the most refractory alloys of iron with silicon and other elements. Ferro-silicon is dissolved in a few minutes when heated with sulphur chloride to from 170 to 212 deg. F. The silicon is carried off in the form of white fumes of silicon chloride. If the reaction takes place in a closed glass vessel no loss occurs, and all the ingredients of the alloy are obtained in forms suitable for further treatment, in 15 minutes.

H. M. S. "VANGUARD."

THE LATEST OF THE BRITISH "DREADNOUGHTS."

THE illustration given herewith shows H. M. S. "Vanguard" as she will be when completed. This ship is an improved "Dreadnought," and she is a sister ship to the "St. Vincent" and the "Collingwood." She is 500 feet long, with a draft of 27 feet and a beam of 84 feet, and her displacement will be about 19,500 tons. The "Vanguard" was launched from the yard at Barrow of Vickers, Sons & Maxim on February 22nd.

The "Vanguard" is to be fitted with turbine machinery of 24,000 horse-power, which it is estimated will give her a speed of 21 knots. It is interesting to note in connection with the recent launching of this ship that she is the heaviest that has ever been launched for any navy. Her weight as she entered the water approached 10,500 tons. The "Vanguard" is being rapidly constructed. It was only April 2nd of last year that she was laid down, and it is hoped that she will be handed over to the Admiralty by the end of March next year. We believe that her armament is to consist of ten 12-inch guns, a number, not yet specified, of 4-inch guns, and torpedo tubes. Her armor amidships is 11 inches thick.—The Engineer.



Horse-power, 24,000. Speed, 21 knots. Displacement, 19,800 tons. Length, 500 feet. Armament: Ten 12-inch guns; unspecified number of 4-inch guns and torpedo tubes Amidship armor, 11 inches.

H. M. S. "VANGUARD."

AERIAL FLIGHT IN THEORY AND PRACTICE.

IN his lecture on the above subject delivered at the Royal Institution, Prof. G. H. Bryan, F.R.S., said that considerable light on the character of the motion of a fluid past an aeroplane was shown by some recent experiments of Mr. W. E. Williams at Bangor. In these experiments a plane was set in motion through water, through which bright spangles had been scattered, and the motion of these spangles was recorded photographically. The velocity of motion in these experiments varied from 0.5 centimeter up to 1.6 centimeters per second. Passing on to the question of stability, Prof. Bryan stated that he had arrived at something like a solution of the problem of automatic longitudinal stability, but he did not give any indication as to what this solution was, or whether it was compatible with the somewhat moderate velocities of flight imposed by the weight with which one horse-power can at present be generated. He gave the impression, however, that he proposed to use square planes, the lifting power of which is relatively very small. Aeroplanes, he said, were liable both to a long and to a short period pitching motion, and in the case of square planes, he said, the short period motion might be dangerous. Lanchester's discussion of the longitudinal stability of the flying-machine was said to be lacking in rigor, and to be applicable only to narrow planes, such, we understood, as those now actually used in practice. Curved aerofoils, with the concave side downward, were, he said, liable to get into positions such that the shift of the center of pressure following a tilt, instead of correcting the tilt, actually increased it. Aerofoils with the concave side upward, on the other hand, were free from this danger, but had less lifting power. A form, concave downward in front and convex behind, combined, he said, to a large degree the advantages of both types.—Engineering.

SYNTHETIC PREPARATION OF AMMONIA.

THE synthetic preparation of ammonia remains practically unsolved. The two gases nitrogen and hydrogen do not react on one another at ordinary temperature; at higher temperature the combination is facilitated by the presence of certain catalyzers like iron, but the resulting ammonia is not stable at 1,000 deg. C., the temperature at which Haber and Oordt experimented. (We should mention, however, that a successful electric-arc process is now spoken of.) It has hence been attempted to make use of metallic nitrides (compounds of metals and nitrogen) and hydrides (compounds of metals and hydrogen); but the just-mentioned experimenters did not find the dissociation pressures of the nitrides and hydrides of calcium and manganese suitable, and E. Baur and Voerman do not recommend chromium-nitride for other reasons. On the suggestion of E. Baur, J. Lipski has hence tried, in the Brunswick Technical College, the compounds of the rare earths, with a certain amount of success. The way in which he proceeds does not look simple. But we remember that after years of failures the preparation of incandescent mantles for lamps became an important industry, and that the rare earths are now obtainable in quantities which their name hardly justifies. Utilization of the rare earths is a very different thing at present from what it was twenty years ago. In preparing the cerium nitride Lipski started either from the metal cerium, which the Elektrochemische Werke Bitterfeld supplied to him, or more frequently from the dioxide of cerium, which he treated with magnesium metal in an atmosphere of nitrogen. The metal cerium is steel-gray, and can be turned, but is inclined to spark; the nitride is a black powder, which evolves ammonia in damp air; the hydride is a reddish or brown substance, which slowly ignites on exposure to air. These compounds were known, but Lipski has studied their dissociation pressures and reactions. He finds that at 200 deg. or 300 deg. C. two reactions yield ammonia: hydrogen and cerium nitride give cerium hydride and ammonia, and nitrogen and cerium hydride yield cerium nitride and ammonia, so that the cerium serves in both cases as carrier to effect the combination of nitrogen and hydrogen; a third possible reaction, the re-liberation of nitrogen from cerium nitride and hydrogen, does not take place to any noteworthy degree. Very small quantities of moisture and of oxygen interfere with the formation of ammonia, however; even in their absence the catalyzers become exhausted after a certain time, but they recover. The cerium compounds need not be pure; the technical ceria is just as efficient as raw material. The ammonia percentage in the gas mixture did not exceed 6.4 per cent, when using cerium nitride, and 1.5 per cent when using the hydride. That would technically be sufficient if these yields could be maintained for long periods; the intimacy of the contact is of importance in this respect, of course.—Engineering.

A HOME-MADE PNEUMATIC ELEVATOR.*

HOW IT WAS BUILT BY AN INGENIOUS MECHANIC.

BY PHILIP BELLOWS.

THE half-tones shown herewith were secured in a large shop in Greater New York and illustrate a little, home-made elevator; at once so simple, effective and ingenious as to call for attention on our part. The concern which I speak of has a tool room which has failed to grow in size as the size of the shops has increased; consequently with the passing of time its capacity has become overtaxed. It was, therefore, decided to open another room overhead for the purpose of taking care of this overtaxed condition. It was then found that someone had to run up and down stairs very often with a resulting loss of time. It was just here that an ingenious mechanic came in with the result that the stairs could be abolished and a further saving of valuable space on the ground floor secured. The power necessary to operate the contrivance is secured from the main air line of the shop; 90 pounds is the working pressure.

Fig. 1 shows the cage; Fig. 2 shows the overhead construction at the top of the shaft; Fig. 3 shows the cylinder. From these three views it will be seen that the whole mechanism is most compact and represents the ideal of simplicity. Referring to Fig. 1, it will be seen that an odd corner has been utilized, and far less space taken up than would have been necessary with anything more bulky than a plain ladder. The upright guides are two galvanized pipes about 1½ inches in size. The platform is about 2 feet square and of hardwood, say 1 inch thick and well cleated underneath. The upright bars are of cold-rolled steel about ⅝ inch, and to them is bolted the cross bar taking the shackle of the rope. The rope is 7/16-inch steel wire cable and runs at the top over a cast-iron sheave set in two angle plates, which in turn are bolted to the ceiling of the upper room. A square hole with about ⅝ inch all-round clearance was sawed in the corner of the latter to allow the elevator to pass through.

After passing over the sheave just referred to, the rope passes horizontally parallel with the ceiling and the wall to another sheave which is a fellow of the first, but attached to the end of the piston rod, as shown in Fig. 4; it then returns and is attached to an eye-bolt attached to a bracket, as shown in Fig. 2. The piston rod is a piece of cold-rolled steel 1 inch in diameter. The piston, as seen in Fig. 5, is a cast-iron block turned 1/64 smaller than the interior of the cylinder. The latter is a piece of drawn-brass tube, 3½ inches in diameter by 4 inches outside, so smooth and true that it was not deemed necessary to bore it. The cup leather shown at the forward end of the piston works admirably. The cylinder ends are blocks of cast iron attached to small sections of wrought-iron angles ⅝ x 6 x 3 inches, which in turn are bolted to the ceiling. In action the pet cock, shown at the rear of cylinder, Figs. 3 and 5, is regulated so that, as the elevator is rising, enough air shall be retained in the cylinder to cushion the piston and prevent sudden shock.

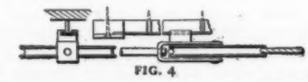


FIG. 4

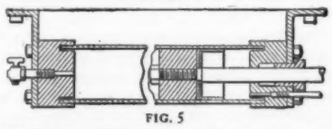


FIG. 5

DETAILS OF SHEAVES AND CYLINDER OF PNEUMATIC ELEVATOR.

To operate the device, after taking your stand on the little platform you pull one side of the continuous cord shown in Fig. 1, and this action opens a three-way valve admitting air from the main to the cylinder. When descending, you operate the cord the reverse way, and this action allows the air which is pent up in the cylinder to return along the feed pipe and find an exit through one passage of the three-way valve into the open air; at the same time, of course, cutting off the communication between the main and cylinder. The hole in the plug of the valve by which the exhaust takes place is about 5/32 inch in diameter, so that the descent is not too sudden.

The sensation of a ride on this simple, yet useful, little elevator is worthy of note. After taking one's stand in the cage the cord is pulled and you expect sudden death, but you become alarmed when you find nothing has happened, and you stand in fear of you know not what for a space of about two seconds. You have just begun to think of giving the trigger a second tug when up you go with an airy bound and your face is on a level with the floor above, a distance of some 14 feet; just about this point the cushion at the back of the cylinder is coming into action and you arrive at your destination with scarcely a jar. The delay at the start is to be accounted for, no doubt, by the time required to fill the pipe and part of the cylinder.

* American Machinist.

It has been estimated that the coal consumption of Great Britain is about 170,000,000 tons per annum. Of this quantity 71,000,000 tons is used in factories and mines, 13,000,000 on the railway systems, and 28,000,000 tons in the iron and steel industries. Take the consumption in factories and mines as 60,000,000 tons for power purposes only; it has further been calculated that if instead of using the coal in boilers for driving steam engines the power required was taken in the form of electricity, and coal used for driving steam turbines and gas engines coupled to generators, this consumption could be reduced by at least 50 per cent Estimating the price of the 30,000,000 tons saved per annum at 7s. 6d. per ton, this represents an annual saving of over £11,000,000. In addition to this the life of the British coalfield would be considerably prolonged.—The Engineer.

FIG. 1.—CAGE OF THE SMALL HOME-MADE PNEUMATIC ELEVATOR.

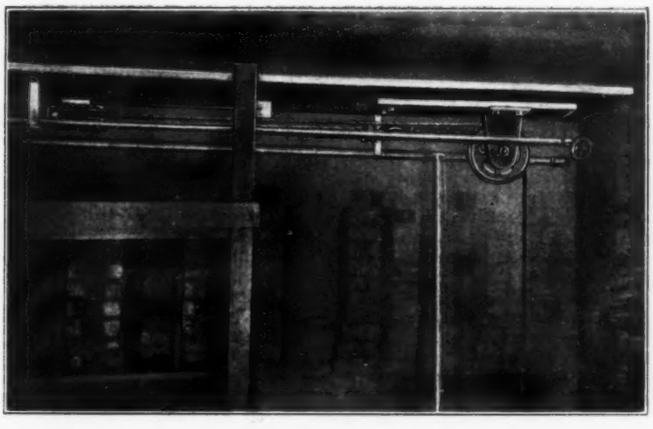


FIG. 2.—OVERHEAD CONSTRUCTION—TOP OF SHAFT OF PNEUMATIC ELEVATOR.

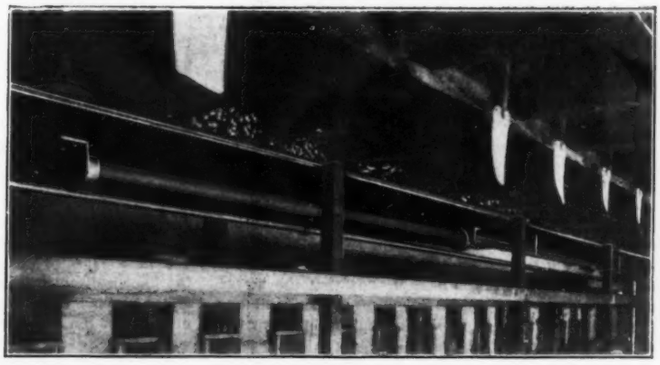


FIG. 3.—CYLINDER OF PNEUMATIC ELEVATOR.

A NEW IDEA IN BLAST FURNACES.

USING A BLAST CONTAINING AN EXCESS OF OXYGEN.

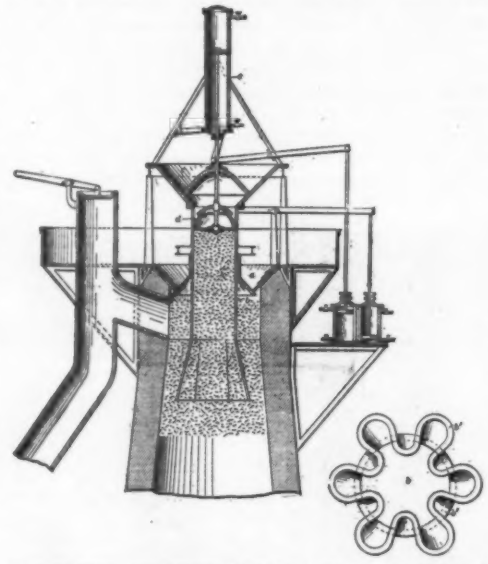
JOSEPH E. JOHNSON, JR., Longdale, Va., has been granted patents on a form of blast furnace construction and a method of blast furnace operation which involve a marked departure from ordinary practice. While the inventions have not yet been practically applied they are of special interest in view of the prominence given Mr. Johnson's studies of blast furnace thermal problems, the results of which he contributed to the discussion of the Gayley dry air blast. It may be recalled that, whereas the early claims of economies secured through the refrigeration of blast for the iron furnace were disputed, Mr. Johnson brought forward a theory of the thermal relations of the blast furnace and a method of figuring them, which have been accepted as explaining accurately this saving. He showed that it is necessary to secure in the blast furnace a certain "critical" temperature, below which it is impossible to accomplish the desired reactions between the fuel, the gases derived therefrom, the ore, and the flux. The energy exerted in bringing the products of combustion up to the critical temperature is unavailable for these reactions, which can only take place at or above that temperature. The efficiency of the furnace, therefore, it was shown, can be greatly increased by adding to the amount of heat available above the critical temperature. This the removal of moisture does.

The introduction to the specifications of the last patent granted Mr. Johnson, that on a new form of blast furnace construction, points out that much of the heat which would otherwise be available for ore reduction is carried off by the nitrogen in the air of the blast, while a smaller yet important quantity of heat is expended in decomposing moisture. Obviously any reductions in the amount of nitrogen and moisture in the blast will increase the amount of heat available for the effective working of the furnace. Previously a patent had been secured on a process of supplying blast containing an excess of oxygen, utilizing the heat in the fuel by passing the gases escaping from the furnace through the incoming body of ore and maintaining them out of contact with the incoming fuel. The form of furnace in which this process is carried out is shown in the picture. Without going into such details of construction as are common to the ordinary blast furnace, attention may be called to the special features. The ore is dumped into the hopper *a*. At the corner of the hopper is a vertically placed mantle, *b*, the upper portion of which is cylindrical, and the lower portion of a fluted cone shape, as illustrated herewith. The mantle has hollow metal walls, the annular space *b'* being adapted to the circulation of cooling water. A conical fuel hopper, *c*, is mounted at the top of the mantle. For charging the fuel a hemispherical pusher, *d*, is provided, attached to a rod which terminates in a piston fitting the cylinder *e*. After charging the fuel into the hopper *c* the bell is raised, allowing the fuel to go in on top of the pusher, which, being raised to its highest position under the bell, allows the fuel to go into the mantle. The pusher is then forced down to the top of the fuel and gives a desired pressure, that in the cylinder *e* being varied at will. The construction, it will be seen, provides a means of feeding the fuel which gives a gas seal intermediate between the mantle and the source of fuel supply. The mantle *b* being fluted the fuel is discharged from it in a fluted or star shaped column surrounded on all sides by the descending ore. There is thus an intimate contact between the ore and fuel. The ore being heavier than the fuel will tend to cut off the descent of the latter, and, therefore, the column of fuel is made higher to compensate for this. The purpose of the pusher is to control the ratio between the amount of ore and fuel charged into the furnace.

Another patent covers a process for the economical extraction from the atmosphere of a large proportion of its oxygen, and this considerable elimination of nitrogen from the blast is a very important feature of Mr. Johnson's proposal. It is figured that the power requirements for this separation of oxygen will not exceed those involved in compressing the blast for the ordinary furnace of 20 pounds pressure. The most revolutionary feature of the entire combination of innovations is that since the oxygen so obtained would not require preheating, the usual hot blast stoves, the gas consumed in them, and all their attachments would be eliminated. It is suggested in connection with the specifications of the patent herewith illustrated that as the purity of the oxygen can be regulated by the adjustment of the apparatus for producing it, such regulation takes the place of the regulation of the temperature of the blast under present practice.

Another very important suggested change which would accompany the successful working of the invention is the use of bituminous coal in place of coke in the blast furnace. This is made possible by charging the fuel in a continuous column of fluted cylindrical section, through which it is not necessary that the gases should pass, this being, in fact, undesirable, since the coherence of the bituminous coal in a solid mass when hot protects it largely from the dissolving action of carbon dioxide. Another point suggested is that the fuel column being in the center of the furnace would be out of contact with the walls, and, therefore, the possibility of hanging is prevented. The gases resulting from the distillation of the coal as it is heated being very combustible and having a powerful deoxidizing effect would pass up through the column of ore and assist in its reduction.

The specification notes that the blast containing an excess of oxygen is not employed to raise the temperature in the furnace, but to increase the amount of heat which at the critical high temperature is requisite for performing that part of the smelting operation which can only take place at the highest temperature—produced by the employment of an air blast. The results of the successful carrying out of Mr. Johnson's proposal are a subject of interesting speculation. Oxygen blast would greatly reduce the total fuel used



PROPOSED CONSTRUCTION OF IRON BLAST FURNACE USING BLAST WITH AN EXCESS OF OXYGEN.

per ton of iron and a large part of that employed would require no coking. With the elimination of nitrogen and the reduction in fuel consumption, the quantity of gas discharged from the furnace would be only a fraction of the present amount. Yet it would not necessarily be less combustible than present furnace gases, even though much more highly oxidized, the removal of inert nitrogen and the addition of volatile matter from a part of the coal being reckoned as offsets. It can be appreciated that the effect of the gases on the ore for a given furnace volume would be more rapid than at present, and that if a sufficient reduction in pressure can be secured through the reduction in volume much has been done to solve the problem of slipping.

The capital requirements for such an innovation are a matter of speculation. It would be a case of putting the cost of apparatus for the separation of oxygen and nitrogen against that of hot blast stoves, taking account also of the smaller outfit of coke ovens per furnace. The greater compression of air called for would probably be regarded as offset by the smaller volume of blast required. As an attempt to cope with the known disadvantages of the iron blast furnace the entire scheme will at least arrest attention. The significance of the successful carrying out of the proposal was recognized in the statement made in the discussion of the dry blast, that the saving by the elimination of moisture is only an index of that which may be expected from the removal of the nitrogen.—Iron Age.

Schultze's White Blasting and Gun Powder.—Thin wooden boards are reduced, with the aid of a crosscut, into small, regular, angular grains, of the size of small pearl-barley grains; in order to remove the sap substances they are repeatedly boiled with dilute soda solution, washed out with water, treated with steam, washed again, and dried, nitrated in a mixture of nitric acid, the acid removed in a centrifugal, the product thoroughly washed out, boiled with a weak soda solution, washed out, dried, saturated with nitrate of potash or baryta solution, and dried.

IMPROVED STEELS.

THE steel trade journals report recent improvements in the methods of steel manufacture which result in products so superior to the regular grades that they have peculiar interest to railways which are large consumers of steel. The electric furnace is rapidly coming into use as an important factor in steel manufacture, and where water power is abundant and fuel is scarce it is extending the boundaries which have for a long time confined the iron and steel districts. Experience with the electric furnace in foreign countries has shown that it will purify the metal to a larger extent than the gas furnace or the Bessemer converter, and it is proposed to use it as an adjunct to the ordinary processes of steel manufacture for the purpose of reducing the amount of phosphorus and sulphur and to deoxidize the bath. After a careful investigation by its metallurgists, the United States Steel Corporation has decided to use a 15-ton Heroult electric furnace at the South Chicago works. Three-phase alternating current will be used, and it is proposed to refine the blown metal from the Bessemer converter in the Heroult furnace, reducing the percentage of phosphorus and sulphur, and to use the product for high-grade steel rails. The capacity of one furnace is sufficient for the production of 500 tons of steel in twenty-four hours. By this method it may be found possible to produce low phosphorus rails at the Bessemer works without resorting to the very expensive measure of substituting the open hearth furnace. This experiment will be made at the South Chicago works during the coming summer.

The Heroult steel refining furnace is of the crucible type with a tilting rack. The heating is initially effected by means of the electric arc which forms between the surface of the slagging materials which float on the metal bath and the two massive carbon electrodes which are suspended above it. The impurities of the steel are removed by renewing the slag. The refining operation thus becomes a "washing out" one. Heroult claims that with this furnace iron or steel of any degree of impurity can be refined, and from the purified metal a steel of any desired composition can be produced by the addition of the necessary amount of carburite and other ferro-alloys.

Another interesting item relates to the developments which are rapidly taking place in the manufacture of high speed steel. The Sheffield, England, steel makers were not satisfied to pay tribute to the Taylor-White Company,* and they have been experimenting with various alloys and heat treatments and have succeeded in producing a tool steel which in some qualities surpasses those previously made. While the extravagant reports in regard to the cutting power of this new steel may not be found to be entirely correct, yet it is well attested that English manufacturers have succeeded in making a high-speed tool steel which has a longer endurance when cutting hard material with the cutting edge at red heat, and it will not crack when plunged into water. Tool steel makers in this country are also improving their product, and there is a prospect of such active competition on both sides of the Atlantic that the railways may soon be able to buy high-speed steel at lower prices.

Vanadium steel is used in large quantities by the automobile manufacturers on account of its superior strength, which allows lighter sections to be used. This quality should recommend it for the machinery of locomotives, especially the reciprocating parts, which are often heavier than is necessary, even when made of ordinary carbon steel. If these parts were designed so that the working stresses had the same factor of safety with relation to the elastic limit of vanadium steel, as for the steel generally used, their weight could be materially reduced. Nickel steel for railway purposes has been a disappointment, both for rails and for machinery, and there appears to be a better prospect for vanadium steel. These high-grade steels cost more money per pound, but there are places in railway structures where the parts are subject to constant vibration, to alternating stresses or to violent shocks, where they may be substituted for carbon steel and in the end not prove so expensive.

The increase in elastic limit obtained by the use of

* The Taylor-White patents have been declared invalid.—ED. SCIENTIFIC AMERICAN SUPPLEMENT.

expensive alloys in spring steel is of little advantage except that it prolongs the life of the spring, for with such material under the same load the ratio of fiber stress to elastic-limit is materially less. In the tests made at the Baldwin Locomotive Works on the effect of different methods of tempering the results showed that while the elastic limit was materially increased it had little effect on the modulus of elasticity. As the deflection under a given load bears a direct relation to the modulus of elasticity it is evident that the deflection under a given load cannot be changed by hard or soft tempering. It is also clear that alloy steels which tend to increase the elastic limit cannot result in a reduction in the number of plates or the weight of the spring. Though the elastic limit may be 50 or 100 per cent greater than that of ordinary spring steel, duplicate springs will act alike under equal loads. The advantage of the improved alloy spring steel must, therefore, be in prolonged life and not in any reduction in weight.—Railroad Age Gazette.

THE EVOLUTION OF HEAT BY LIVING FOLIAGE.

A CURIOUS PHENOMENON OF PLANTS.

BY PROF. HANS MOLISCH.

THERE is a story of a blind woman of Madagascar who accidentally touched the flowers of a climbing plant of the Arum family and found them surprisingly warm. As a matter of fact the flowers of many aroids develop by their active respiration heat enough to make them from 8 to 30 or more Fahrenheit degrees hotter than the surrounding air. A similar elevation of temperature occurs in the male flowers of cycads and the pistils of *Victoria regia*, many palms, and other plants.

In order to show the production of heat by the respiration of plants, teachers usually select flowers or sprouting seeds either of which when collected in large quantities and surrounded by poor conductors of heat, develop a rise of temperature that can be detected with an ordinary thermometer. Horse dung, hay, tan bark, cotton, and other lifeless vegetable substances often "heat" and increase in temperature by more than 100 deg. F., but here also the real sources of heat are living organisms, the bacteria of putrefaction.

All living organisms, both vegetable and animal, breathe, oxidize, and consume organic matter and thereby produce heat. The heat thus developed in plants is in most cases lost so rapidly by radiation and evaporation of water that it is not detected, but when these losses are reduced to a minimum the development of heat becomes very perceptible. Flowers or sprouting seeds are usually employed for such experiments, and the production of heat by leaves has been ignored or underestimated. I have discovered, however, that freshly plucked green and still living leaves of many plants, collected in large masses, become heated by their own respiration, without the aid of bacteria, so rapidly that in many cases they are killed in a few hours.

For example, about 7 pounds of freshly-plucked leaves of the hornbeam (*Carpinus*) were placed in a basket, which they completely filled, and a thermometer was inserted among them. The basket was packed in wood wool in a modern box, which was wrapped with cloths, and placed in a room where the temperature remained nearly constant at about 73 deg. F. The thermometer inserted in the mass of leaves rose (from 72 deg. F.) to 111 deg. F. in 9 hours, and to nearly 125 deg. F. in 15 hours. During the following 37 hours the temperature of the leaves fell to 93 deg. F., then rose to a second maximum of 117 deg. F., and thence fell slowly to the temperature of the room.

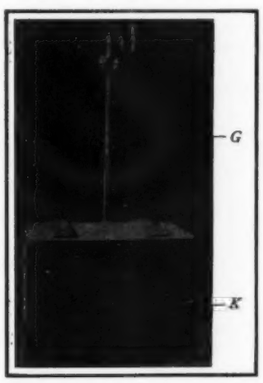
The maximum temperatures and the time required to attain them by leaves of various plants are given in the following table:

Species.	Temperature of Air. Deg. F.	Maximum Temperature of Leaves. Deg. F.	Hours.
Pear	59	138	27
Hornbeam .	73	125	15
Locust	75	124	13
Linden	64	123	27½
Walnut	59	121	43½
Willow	59	117	22
Laburnum...	64	114	18½
Grape	63	110	28

In all these cases the maxima are very high, but not all leaves develop so much heat. Much lower maxima are shown by leaves of canna, tradescantia, ivy, Norway spruce, and other plants. In general, the leaves of monocotyledonous and evergreen plants, and leaves which remain fresh long after plucking, produce little heat.

With leaves that exhibit a great rise of temperature two maxima are generally observed, if sufficient material is used. As we have seen in the case of the hornbeam, the temperature rises rapidly to a maximum sufficiently high to scald and kill the leaves and then falls, but subsequently rises to a second maximum. The upper limit of temperature for the life of most leaves lies between 113 and 122 deg. F. If the experiment is interrupted when the temperature is near this limit—say 105 deg. F.—the leaves are found to be still alive and fresh, and capable of living many days if laid in water. The leaves are also found to contain approximately the same number of bacteria as when plucked, so that the elevation of temperature must be chiefly due to the heat developed by the respiration of the leaves themselves. But after the upper vital limit of temperature has been reached the dead leaves furnish a field favorable to the growth of bacteria and fungi, which multiply rapidly and raise the temperature to the second maximum by means of the heat produced by their very active respiration. In short, the first rise is due to the vital activity of the leaves, the second to fungous organisms.

The spontaneous heating of leaves can be strikingly exhibited by a lecture experiment, in which ether is boiled by the heat produced. For this purpose I use a glass tube about 3 feet long, closed at one end and blown out into a bulb near the open end. This tube is fitted to one-third its height with colored ether and the closed end is inserted into the mass of leaves. As ether boils at 94 deg. F. it will boil briskly if the



ETHER BOILED BY THE HEAT PRODUCED BY THE RESPIRATION OF LEAVES.

temperature of the leaves is much above 100 deg. F. and the ebullition can be seen clearly from a considerable distance.

It seems very remarkable that an organ of a plant should be killed by its own respiration, a normal vital process, but the leaf is never killed in this way while it remains on the plant, as the heat produced is rapidly carried away by radiation and evaporation.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

GERMAN CANARY BIRDS.

THE export of canary birds to the United States from this district during the year 1908 amounted in value to $130,355, against $136,354 in 1907. It is estimated that there are not less than 5,000,000 caged birds in the United States. The ordinary house canary will eat 25 pounds of seed a year, which costs an average for each bird $1.50. It will be seen that this luxury represents an outlay on the part of the American people of $7,500,000 annually for feed alone. In regard to the German exports to the United States, principally of Harz Mountain singers or breeders, one of the largest exporters of birds in Germany says in a letter to the United States consulate at Hanover:

"I place the number of canary birds exported from Germany to the United States per year at 250,000. There are probably 5,000,000 caged birds in the United States. My firm exports yearly nearly 150,000 birds from this district; the number exported by other firms in the districts of Brunswick, Hamburg, and Bremen I estimate at about 100,000 birds. The average wholesale price for a male bird is 3 marks ($0.714) and for females 70 pfennigs ($0.17). While the American demand has increased, the cost price at home has risen and it has been very difficult to raise the selling price in America. In proportion to other luxuries in the United States canaries are cheap, as they are usually bought by the poorer classes; on this account as soon as prices are raised there the demand immediately falls off. The financial stringency during the past year has had no appreciable effect on the demand for birds and holiday business was very good. It is a fortunate thing for the breeder that the birds do not live long in the United States. If this were not the case, our export would soon be at an end.

"I have observed that the proposition has been made on different occasions that the breeding of canaries in great quantities in the United States might be profitable, but in my judgment this would prove a failure. For breeding purposes Germany is the most favorable place perhaps in the world; especially is this so in the country, where every farmer and workman has his small house, and for that reason has room to breed the birds. We buy from these people. Furthermore, German breeders as a rule are not too ambitious as to profits. A good deal of skill, luck, and care is absolutely necessary in order to be a successful breeder. The American would not be satisfied with the small profit arising from the breeding and, on the other hand, the demand would cease with the increase of prices."

NEW SOLVENTS OF FATTY SUBSTANCES.

THE qualities required of a solvent in manufactures of fatty substances are the following: The liquid should possess a maximum power of extracting fatty matter from the raw material, be non-inflammable and non-poisonous, have a low boiling point and specific heat (in order to save fuel used in evaporating), be removable from the finished product so completely as to leave no taste or odor, exert no chemical action on material or apparatus and, finally, be not too costly for industrial use. None of the solvents currently employed satisfies all these conditions.

Carbon tetrachloride, on which great hopes were founded, seriously attacks most of the metals used in the construction of apparatus.

The following chlorinated derivatives of the hydrocarbons ethane and ethylene offer many advantages:

Name.	Formula.	Boiling Point.	Sp. Gr.
Dichlorethylene,	$C_2H_2Cl_2$	131 deg. F.	1.25
Trichlorethylene,	C_2HCl_3	190 deg. F.	1.47
Tetrachlorethylene,	C_2Cl_4	250 deg. F.	1.62
Tetrachlorethane,	$C_2H_2Cl_4$	297 deg. F.	1.60
Pentachlorethane,	C_2HCl_5	318 deg. F.	1.70

All of these solvents are very stable and chemically inert liquids and the wide range of their boiling points makes them valuable in numerous industries. All are non-inflammable and the ethylene derivatives exert no chemical action on oils and fats, or on iron, zinc, copper or lead, even in presence of moisture. Trichlorethylene is, in general, the most suitable for use in manufactures of fatty substances. Its boiling point differs little from that of benzol and it costs little more than carbon tetrachloride. Its latent heat of vaporization is about 33 calories per kilogramme, or 59 British heat units per pound. It is inoffensive, non-inflammable and without physical or chemical action on the substances which it dissolves. Dichlorethylene is a very useful substitute for ether. Tetrachlorethane is a good solvent of fats, resins, and cellulose acetate. At 248 deg. F. it dissolves and mixes in all proportions with sulphur, of which it deposits 99 per cent in fine crystals on cooling.

THE RAYS OF URANIUM X.

MR. FREDERICK SODDY has carried out a second series of observations designed to detect the growth, if any, of a feeble α radiation during the decay of the intense β radiation of uranium X.

The observations indicate that the α radiation remains constant after the maximum is reached over a period of several years. This points to the existence of a new body, presumably somewhere in the uranium series, with a period of the order of one day, the product of which gives α rays, and has a very long period of life.

THE FLIGHT OF BIRDS.—II.*

THE MECHANICS OF A BIRD'S WAY IN THE AIR.

BY F. W. LANCHESTER.

Concluded from Supplement No. 1740, page 302.

So FAR as the author is aware, it was Pettigrew who first pointed out the analogy between the action of a bird's wing and that of the blade of a screw propeller, but he apparently made but little real use of the idea. It appears to the author that a very great deal of that which is essential in the active mode of flight may be learned by the study and development of the screw propeller analogy.

When one watches a moor hen swimming by means of its wings under water, the wings are seen to behave as elastic flaps attached to rigid pillars by their anterior margins, so that as the said pillars move up and down about their articulations as pivots, the elastic flaps act alternately as right and left-handed screw blades, and so propel the bird in a forward direction. It is evident that the wings act equally on both up and down strokes, for the moor hen is of approximately the same specific gravity as water, so that the

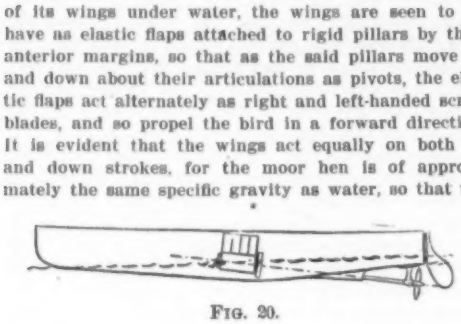


FIG. 20.

wings have no weight to sustain, and their action is thus strictly that of propeller blades.

When the bird is employing its wings for flight the conditions are different, for they then serve to sustain as well as to propel. Now, when a screw propeller is mounted on a shaft inclined to the direction of motion, as frequently is the case (Fig. 20) it is easy to show that it also gives a sustaining as well as a propelling reaction, so that the analogy may still hold.

Thus, in Fig. 21, we may suppose in the various diagrams *a*, *b*, *c*, etc., two positions of the propeller blade are given, corresponding to the beginning and end of a short interval of time. In the upper diagram the blade is supposed to be ascending, and in the lower figures descending. Then, the distance *o p* being the motion of translation during the said interval of time, it is evident that in diagram 21*b* the whole of the propulsion will be done by the descending blade, which will experience an upward reaction, while the upward-moving blade will be idle. In diagram 21*a* both ascending and descending blades experience an upward reaction. In diagram 21*c* both blades are assisting in the propulsion, but most work is done by the descending blade, and although the reaction on the ascending blade is downward, it is less than the upward reaction on the descending blade. These three diagrams represent three points, chosen at different distances radially along the blade of a propeller.

If the incline of the shaft be correctly adjusted for the purpose of our analogy, some point along the blade of the propeller will, as in diagram *b*, do the whole of its work on the down stroke. At points nearer the blade extremities there will be a propulsive component on both up and down strokes; at points farther from the blade extremities there will be a continuous but fluctuating sustaining reaction. In all probability the bird's wing is far from being an exact

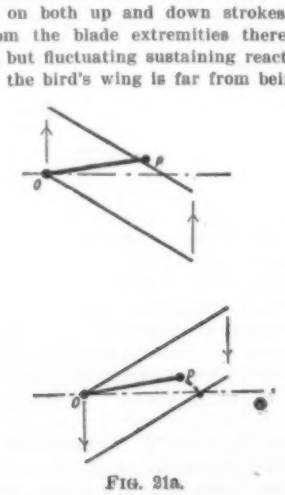


FIG. 21a.

helical form, as assumed in the propeller analogy. Nevertheless, the main facts, without doubt, apply, i. e., the wings behave as blades of a screw propeller, mounted on an inclined axis.

When one of the smaller birds rises from the ground, and until it has reached its normal velocity of flight, the axis of the equivalent screw must be regarded as inclined at a greater angle than is ordinarily the case, in fact for the first instant the axis is approximately vertical (Fig. 22). In the case of a pigeon it is often noticed that the wings each swing through a full 180 deg. so that they may sometimes be heard to smite each other with considerable noise. Under these conditions we may closely imitate the motion by means of two single-bladed propellers of opposite hand and rotation (Fig. 23); the blades changing places at the points where the direction of motion and pitch change in the real bird.

We may similarly represent the wings of a bird in full flight by two propellers of say three blades (Fig. 24) in which the blades are supposed to vanish and come into existence again as they pass into and out of the shaded areas.

In reality wing motion is far more complex than might be gathered from these diagrams, and it is difficult even with the beautiful chronographic records of Prof. Marey to make out the complete details. The main observable departure from the simple screw-like motion appears to be that the wing is partially folded or flexed on each up stroke. This action is in all probability one of purely dynamic import; the upward motion of the wing being roughly as represented in Fig. 26, it is evident that the reversal of the wing motion when it reaches the top causes a certain stress on the pectoral muscle, and this is diminished owing to the fact that the inertia is taken up in giving a final flick to the terminal portion of the wing, which expends the energy so received in propulsion, for we

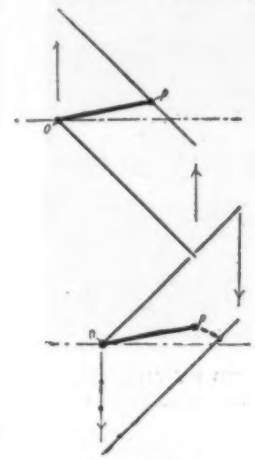


FIG. 21b.

have seen that the terminal portion of the wing is propelling on both up and down strokes. On the up stroke of the wing the part close to the fulcrum is still acting to sustain the load, so that it is actually receiving energy from the aerodynamic reaction. This during the early part of the up stroke is advantageous, as it supplies the necessary upward acceleration, and so relieves the second pectoral muscle.* By the delay in the return of the terminal part of the wing the resistance is, as it were, saved to the last, and so is used to arrest the wing motion as above described.

The reality of the screw-propeller theory of wing motion receives very substantial support in the fact that the general run of the motion, relatively to the bird, Fig. 25, is in a direction that corresponds with the plane of rotation of the hypothetical propeller by which the action of the wing is represented.

The question of the efficiency of wing propulsion is one that has never been adequately dealt with. There is an idea lurking in the minds of many workers that wing propulsion is far more efficient than the best result obtainable with the screw propeller; it is a question whether this view can be substantiated. On the face of it wing action is not liable to the loss of kinetic energy imparted to the fluid by a screw propeller at right angles to the line of flight, since this motion can be imparted in a downward direction, and so serves the purpose of sustentation. We will examine this question more closely.

Let us suppose, Fig. 27, that the mass of the bird or aerodone be suspended from an aerofoil by means of a rope, and as the aerofoil descends in its gliding path, let us suppose that the bird climbs up the rope to maintain its level constant by mechanism of perfect efficiency; we may take it also that the rope and aerofoil are without weight. Then so long as the process can continue the expenditure of energy will be just that done by gravity in ordinary gliding descent; the efficiency is, therefore, 100 per cent. In order to suppose the process continuous we will take it that when

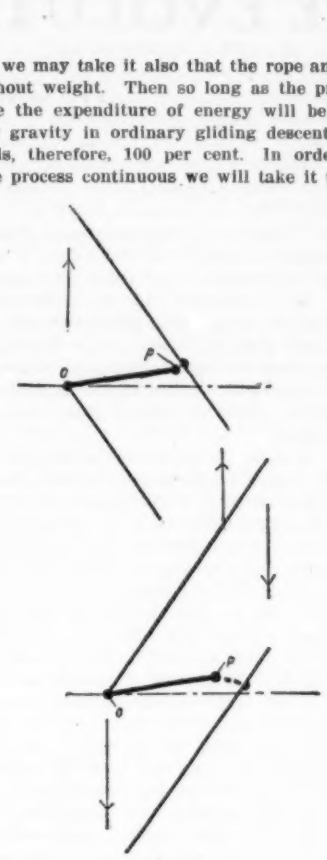


FIG. 21c.

the rope is all absorbed we abandon the aerofoil and create a new one at a convenient altitude with a new rope to climb; it is evident that since neither aerofoil nor rope possesses weight no energy will have been expended in the transformation, and the efficiency will be as before—100 per cent. Now, since we cannot really create a new aerofoil at intervals it is necessary that we should lift the old one up to its initial position after each climb, and the system with a little modification of mechanical detail becomes a system of flying with an aerofoil worked with a parallel motion instead of an angular movement, as in the flight of birds. We will assume, in order to simulate bird flight as closely as possible, that the lifting and descent of the aerofoil occupy two equal periods, and that during its lift the aerofoil slides through the air edgewise with no resistance other than skin friction. Then this skin friction on the aerofoil represents the energy lost.

In Fig. 28 the weight is shown sustained during the up-stroke of one aerofoil by the simultaneous down-stroke of another, the supposition being that the mechanism is duplicated so as to give uniform sustentation. This arrangement would be analogous to that of a bird fitted with two pairs of wings after the manner of a dragon-fly, the motion of the two pairs being presumed to be in opposite phase. The action is not materially affected if only one aerofoil be employed, but in this case the flight path (Fig. 28) will be an undu-

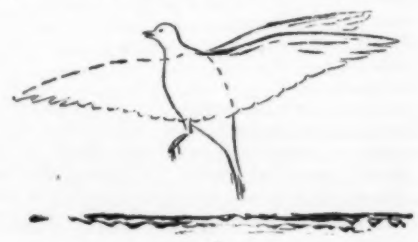


FIG. 22.

lating curve instead of a straight line; during the periods of sustentation the mass center will be in the hollow of an undulation, with intervals of projectile flight, between the said periods as in the leaping or bounding variety of flight.*

It is evident, therefore, that the necessity for returning the aerofoil to its initial position after each working stroke involves a loss of energy equivalent

* Read before the Birmingham Natural History and Philosophical Society.

* This is the muscle by which the wing is elevated.

* "Aerial Flight," vol. i, Aerodynamics, appendix iv.

to doubling the coefficient of skin friction. If the aerofoil were in the first instance designed for least resistance, the author has shown that the skin-frictional resistance will be just half the total resistance; hence unless we readjust the design to suit the new conditions the return stroke uses half as much energy as the working stroke, and the efficiency will be 66.6 per cent. It is evident, however, that for best efficiency the wing area must be altered to continue to comply with the conditions of least resistance, and the new design will be given by employing a coefficient of skin friction double of its actual value. Theory shows that this will give a resistance $\sqrt{2}$ times greater than previously, approximately in the relation 10:7; thus the efficiency will be about 70 per cent.

Now, in the case of wing motion the angular character of the movement renders the problem more complicated, but the author will venture the suggestion that whatever in actual wing motion does not partake of the action of a screw propeller is accounted for as above, and that which does partake of the screw propeller is subject to the loss of efficiency inherent to the screw propeller in its simplicity; hence the efficiency of wing propulsion will lie between the value above obtained and that proper to a well-formed screw propeller.

Now, it is a fact that serves our present purpose exceedingly well that, so far as we have knowledge, the best efficiency obtainable with the screw propeller is approximately the same as obtained above for the reciprocating aerofoil; hence there is every reason to believe that wing propulsion has an efficiency of approximately 70 per cent, and thus possesses no advantage on the score of efficiency over a well-designed screw.

The possibility or otherwise from a physiological point of view of a bird being able to generate sufficient power for flight is a ground on which estimates of power expenditure have sometimes been challenged. It must be remembered that birds of over about 1 pound weight have, generally speaking, a very limited capacity for active flight; they principally employ the soaring mode. It must also be remembered that the power varies as L^2 law applies very closely to animal life as well as to machines, and that a direct consequence of this law is that the rate at which an animal can increase its altitude is—other things being equal—inversely proportional to the cube root of its weight.

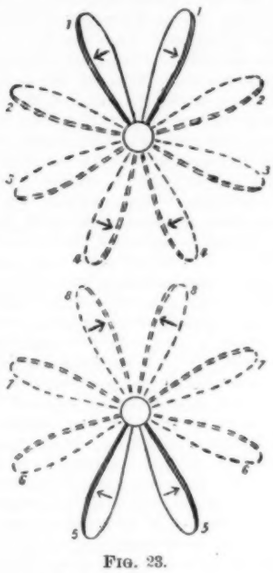


FIG. 23.

Let us take the homing pigeon and the horse for purposes of comparison; although the two, considered as machines, are of widely different type, both have been bred carefully as power producers, and the comparison should yield results of the right order.

Assume, as indicated in the present paper, a gliding angle = 1 in 6 and a flight velocity of 54 feet per second; that is to say, the rate of gliding descent will be 54/6 = 9 feet per second, or, taking the efficiency of wing propulsion as estimated at 70 per cent, this corresponds to an increase of 13 feet per second altitude as representing the work done in flight. Taking the horse as weighing equal to 1,300 pigeons, say (11^3) pigeons, we have the rate at which a horse should be able to increase its altitude 13/11, or 1.18 feet.

There seems nothing improbable in the above result, for a horse of 1,200 pounds weight it is equivalent to slightly over 2¼ horse-power, an output of which such a horse should be capable for quite a considerable time daily. It would thus appear that the limiting size of birds of active habit may be approximately predicted by modern flight theory from the known working capacity of a horse.

There is a variety of active flight practised more particularly by some of the smaller species which the author has termed "leaping" or "bounding" flight. In this mode the bird may be seen to progress through the air by a series of bounds; close observation shows that the "take-off" consists of a period of active flight, and the leap is a simple parabolic trajectory performed

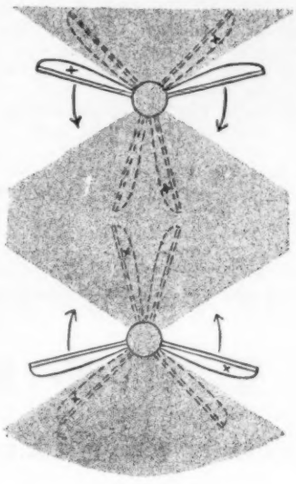


FIG. 24.

like a projectile with the wings closed. The author has discussed this mode of flight in his "Aerodynamics";* it may be accounted for on the grounds that the bird when exceeding its normal velocity of flight—that for which it is designed—endeavors to approximate to the conditions of least resistance by closing its wings intermittently to obviate skin friction. The faster the bird flies the shorter relatively becomes the active period; this is as theory requires. It is worthy of note that apart from body resistance the energy expended for a given distance will be approximately the same, whether the bird is flying steadily at its normal velocity, or whether it be flying at an accelerated velocity by the leaping method.

It is only the smaller birds that indulge in the leaping mode of flight; it is a very common mode of progression among the wagtail group; the largest exponent of the leaping mode observed by the author is the green woodpecker. The reason for this limitation is the question of size as affecting power development, with which we are already familiar. Thus let us suppose that a given bird be correctly proportioned for flight at, say, 40 miles per hour, and that its maximum sustained power output is just sufficient for flight at this velocity; then in the case of a geometrically similar bird, the law of corresponding speed will give the velocity for which it is correctly proportioned, and this velocity for a bird of half the linear size will be 40 divided by $\sqrt{2}$, or approximately 29 miles per hour. But such a bird will, at this speed, have an enormous surplus of power at command, for it should be capable of lifting itself at twice the rate of the larger bird, and thus of flying at a far greater velocity; hence, although adapted by design for a velocity of only 29 miles per hour, it can, by adopting the leaping mode, attain a much higher speed; in fact, on elementary theoretical grounds at least, it should be thus capable of a speed higher than that of the larger bird. The body resistance probably becomes formidable when the smaller bird flies as fast as the larger, and puts a limit on this conclusion.

Another field in which the horse-power weight factor is of moment is in the capacity of a bird for stationary

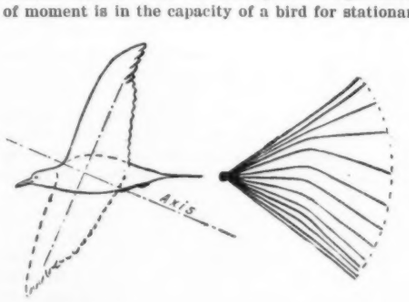


FIG. 25. FIG. 26.

flight, and hand in hand with this the capacity to rise from the ground without a preliminary run; again the advantage obviously rests with the smaller bird, a conclusion that is fully borne out by observation.

There is one kind of flight that must be admitted to be a vexed question. According to observers having a reputation for accuracy, the migrations of birds are carried out at almost incredible velocities, running sometimes into hundreds of miles per hour. It is quite possible that flights of this kind sometimes occur, but it would be absurd to suppose that the said velocity is that of flight; it rather represents the velocity of some great aerial current on which the bird is borne, and of which the flight velocity of the bird constitutes but a small and unimportant part. If this conclusion is at fault, the phenomenon of migratory flight must be something quite apart from that of flight under normal conditions. The rarefaction of the air at high altitudes may account for some increase in the flight velocity under the conditions of migration, but theory gives the increase on this score as inversely proportional to the square root of the density, an amount which is quite inadequate as an explanation.

* Appendix iv.

THE THEORY OF DYEING.

By S. H. HIGGINS, M.Sc.

PERHAPS there is no part of chemistry concerning which so many speculations have been made, and so few really quantitative experiments carried out, as that portion dealing with the actions taking place during dyeing operations. Many observations have been made and deductions drawn, but yet there is a surprising lack, in this branch of applied chemistry, of the large amount of accurate work which is so characteristic of practically all other branches of chemical science. The art of dyeing is very old, for Pliny observed polygenetic color dyeing and the application of different mordants; nevertheless, we have not progressed very far toward a true explanation of the phenomena observed during the dyeing of textile fibers.

The different theories which have been advanced may be divided into (1) the chemical theory; (2) the solution theory; (3) the mechanical theory. It is true that other theories also exist of the nature of chemico-

FIG. 27.

mechanical, but the above are the definite classes of opinion. The chemist with pardonable pride attempts to explain the process by saying that chemical combination takes place during dyeing, and that the product is mainly the result of chemical action between the fiber and the dye-stuff. He is imbued with the all-embracing nature of his science, and resembles the apostle of electrolytic dissociation who is busy attributing all chemical actions to the whims of those mysteries—the ions.

It is evident from the literature which is issued from time to time that most investigators of the dyeing process support the chemical theory; but it is also noticeable that most of their conclusions are based

FIG. 28.

upon investigations of animal fibers, as silk and wool, whereas the actions taking place during the dyeing of vegetable fibers, as cotton and linen, have been left almost entirely without elucidation. It is maintained that silk and wool are capable of entering into definite chemical reactions with dye-stuffs, but whereas it is realized that cellulose, which is the chief constituent of vegetable fibers, cannot exhibit strong acidic or basic properties, yet the vegetable kingdom is left alone, and broad generalizations are made from experiments on the other fibers mentioned. At the outset it must be recognized that any theory of dyeing must include all classes of dyeing operations.

The solution theory was advanced in 1890 by Witt, and was the attempted application of the solid solution theory of physical chemistry to explain the phenomena observed during dyeing operations. This theory displayed the genius of its author, and afforded plausible explanations of many experiments, but in other respects it was found lacking. Witt drew attention to the fact that wool dyed with magenta was of the same color as a water solution of magenta, and not the dark green color of the magenta crystals. He said that this observation supported his contention that the magenta was dissolved in the wool. It was shown by Von Georgevics, however, that if magenta crystals are only made fine enough they also exhibit the red color of the solution in water. Further, Walker and Appleyard, working with picric acid, made observations which were incomparable with Witt's conclusions, and thus the new theory of dyeing was shaken at its foundation.

The formation of theories is usually left to the greatest minds, to those of a philosophical turn, and it is possible that in this selection long experience

of practical dyeing has seldom entered into the formulations.

The mechanical theory is to the effect that the dye-stuff is drawn from solution and held in some peculiar physical manner by the fiber. Walter Crum gave a splendid exposition of this view in the sixties, but since that time chemical theory has been so much in evidence and chemical explanations so plausible that the process of dyeing has had to fall in and submit to the popular explanation. Nevertheless, on reading Crum's work one cannot help being struck with its merit, and one marvels that, in spite of this well-known work, the chemical theory of dyeing has gained so many adherents.

In support of the mechanical theory of dyeing some papers have recently been issued, e. g., Hübner, "Experimental Investigation of the Process of Dyeing" (Trans. Chem. Soc., 1907). It is well known that charcoal and other solids possess the property of extracting dye-stuffs from solution; in the case of charcoal the tinting effect is not noticeable, but if a white substance, as China clay, be used, then it is seen that the solid is dyed. It has been stated that in such cases the dye-stuff can be wholly washed out by water, but Hübner showed that these solids behaved either like wool or like cotton during the treatment with water to remove the dye-stuff. Thus it was found that charcoal behaved similarly to wool during every treatment to which wool is submitted in commercial dyeing, and likewise graphite was found to fall in with the usual methods of dyeing cotton; in both cases the fastness to washing was similar.

In pursuance of this line of research the present writer has recently issued (Higgins, Journ. Soc. Chem. Ind., 1909, xxviii, 188) an account of experiments which further support the mechanical theory of dyeing. Wool was beaten in a beating engine to five different states of division, and the samples obtained were dried. They were then allowed to absorb dye-stuff from solution and moisture from the air. It was found that the maximum absorption of dye-stuff and of moisture took place during, approximately, the same time, and that this maximum amount in both cases was practically constant for all states of division. Samples of cotton mercerized, bleached, and unbleached, were found to absorb iodine from weak potassium iodide solution in proportion as they absorbed moisture from the air. A striking result was obtained by plotting the moisture contents of cotton yarn mercerized with different strengths of caustic soda solution. The moisture curve was found to closely resemble the dye trial curve obtained when a substantive cotton dye-stuff was used; in short, the mercerized cotton samples only absorbed more dye-stuff in so far as they absorbed more moisture. The experiments bring out a marked similarity between the absorption by textile fibers of a solid from a liquid medium, and of a vapor from a gaseous medium, and as the absorption of moisture from air is relegated to that class of little understood phenomena known as surface attraction, it must therefore be taken that the dyeing of textile fibers also belongs to that class of physical action.—Chemical News.

LIFE IN OTHER WORLDS.

THE INTERPRETATION OF PLANETARY MARKINGS.

BY F. W. HENKEL, B.A., F.R.A.S.

THE question of the habitability of "other worlds than ours" has always been of great interest to us as inhabitants of this earth, and speculations have at all times been entertained as to the probable nature and mode of existence of extra-terrestrial beings. Fontenelle, an ingenious French writer of some note in the early eighteenth century, composed a series of dialogues between himself and a fashionable lady, "the Marchioness," on the different planets of the solar system, attributing to them inhabitants whose qualities were in accordance with the influences respectively attributed to these bodies in astrological systems. The inhabitants of Mercury were of hot, "mercurial" temperament, those of Venus soft and amorous by nature, those of Mars warlike and belligerent, and so forth. In later times, the famous Dr. Whewell indulged in some speculations as to the possible physical nature of the inhabitants of the various planets of our system.

However, it must be confessed that little scientific evidence, one way or the other, exists as to such matters, and, indeed, there are many who consider—not altogether without reason on their side—that our earth alone in the universe is the abode of organized beings. This, no doubt, may seem an extreme view, though it may at once be conceded that it is not easy to imagine how many of the forms of life with which we are conversant on this planet could exist even on the nearest of our neighbors in space. The very variety of conditions under which we know life to be possible here, however, should of itself preclude us from asserting that life can only exist, in our own solar system at least, on this planet. Nothing seems to prevent the existence of totally different beings on every one of the planets (with the possible exception of the moon), organized and just as fitted for the conditions of their existence as we are for our own. As for the "fixed" stars, though their intense heat seems to preclude the present existence of life, yet, as they are in all probability surrounded by revolving planets not unlike those in our own system, there is no doubt that on some of these latter conditions prevail more or less akin to those existing here. Where we know nothing we may speculate without fear of contradiction.

Our own solar system presents a considerable variety of bodies at varying distances from their central orb, and of very various sizes. The great distances of the planets Jupiter and Saturn from the sun, and the probability that their surfaces are still more or less incandescent, seem to be against the possibility of their being inhabited, though there is no reason whatever, so far as we know, why some of their satellites, at least, should not be the abode of living beings. The planet Mercury, from its proximity to the sun, and from its turning one side only toward the latter, seems at present unfitted for habitation. The case is different, however, with Venus and Mars, our two nearest neighbors in the planetary system. Though much less is known as to the physical conditions of Venus than might be expected from its comparative proximity, approaching as it does at times within 26,000,000 miles, a distance less than that of any other heavenly body (the moon only excepted), yet sufficient is known to show a considerable analogy of conditions with those prevailing on our own planet. Its size is slightly less than that of the earth (diameter 7,700 miles, surface and volume correspondingly less than in our planet), and from markings detected on its surface, it has been concluded that it turns round once on its own axis in a period of 23 h. 21 m., so that its "day" is nearly of the same length as our own, though some have contended for a much longer period. Observers in Italy and other more favored regions have distinctly recognized markings on the planet's surface indicating the existence of continents and oceans "dimly visible," while intensely bright spots, like the polar caps so well seen on Mars, have also been seen at times. Schröter and other observers long ago concluded the existence of high mountains upon the surface. When Venus is near the sun, distinct evidence of the existence of an extensive atmosphere twice as dense as our own is obtained, and the spectroscope shows the presence of water-vapor in some abundance. The dark portion of the planet's disk (that turned away from the sun) is occasionally seen faintly illuminated, in a manner, says Prof. Young, recalling the aurora and other electrical manifestations on the earth.

For a long time more or less conflicting evidence as to the existence of a possible satellite or attendant on Venus was given; but it seems fairly certain that if any such body exists it must be a very small object. On the other hand, the absence of a "moon" is to a great extent made up for by the earth. It may, perhaps, seem strange to some to think of our own apparently dark earth as a luminary; but there is no doubt that, as seen from Venus, if there are any inhabitants, it must be at times a brilliant object. When Venus is nearest to the earth (nearly between earth and sun), its dark side is turned toward us, and, being also in the region of the sky close to the sun, it is invisible to us (except on the rare occasion of a "transit"); but, on the other hand, the earth, having its illuminated side turned wholly toward Venus, must be conspicuously visible as a "full" disk of its maximum size, shining during the night, in the sun's absence, with a brilliancy greatly exceeding the maximum brightness of Venus as seen by us. Thus the want of a moon to the planet may be to a great extent made up for in this way.

The distance of Venus from the sun is only about three-quarters that of the earth, or about 67,000,000 miles, so that any area of its surface must receive about twice the amount of light and heat that an equal area on the earth receives; but, as we have already said, the presence of a more extensive atmosphere may to a considerable extent mitigate this, to our idea, excessive amount.

"In size, density, and general constitution," says Prof. Young, "this planet is our earth's twin sister." Its diameter is slightly smaller, its period of rotation slightly less (day), while its year is only a little over seven months. Air, water, lands, continents, mountains, polar snows, etc., all seem to be present. Thus, so far as our limited knowledge extends, the evidence for the existence of living beings, of a character not so very dissimilar from those with which we are familiar, seems as complete as we can reasonably expect.

Turning now to Mars, we meet with a planet very considerably smaller. Its diameter is only about 4,200 miles, its mass less than one-ninth that of our own earth, and its volume only one-seventh. Its distance from the sun varies from about 135 to 148 millions of miles, and it completes one revolution in 687 days, turning on its axis once in 24 hours 37 minutes. Its equator makes an angle with the plane of its orbit of about 25 deg., which is not much greater than the angle between the earth's equator and its orbit; so that, so far as the seasons depend upon this condition, there should not be much difference in this respect for the two planets. Like our own earth, Mars is not quite spherical, but slightly flattened at the pole, and this flattening is nearly the same in both cases. There are two small satellites, or moons; but they were only discovered in 1877 by the Washington observers with the great 26-inch refractor. Neither of these bodies exceeds ten miles in diameter, so that they cannot give much light to their primary, or produce any considerable tides. Phobos, the inner of these two satellites, revolves round Mars in less than eight hours—a period much shorter than that in which the planet makes one rotation on its axis. Thus it will appear to rise in the west and set in the east. The outer satellite, Deimos, will rise in the east, like the other heavenly bodies; but its orbital motion in the reverse direction is nearly as great, so that it will take about 130 hours between rising and setting, undergoing all its changes of phase—"new," "full," etc. —four times in that interval, its period of revolution being only thirty hours. Frequent eclipses of these satellites and transits across the sun's disk take place.

In a small telescope some markings may usually be detected upon the planet's surface. In a more powerful instrument much detail can be perceived. The planet's disk will be seen to be not so distinctly reddish as it appears to the naked eye, but still of that color, though there will also be found green and purple patches of more or less distinct outlines. Near either pole are to be seen brilliant white spots, which periodically increase and diminish according to their respective presentation away from or toward the sun, the spot at the pole turned away from the sun increasing, the other diminishing, just like the polar snows on our planet, whence the idea naturally arose that these spots on Mars are due to a similar cause. The details of the surface vary considerably from time to time. Spots and markings seen distinctly at one time are scarcely visible at another, while other markings are seen instead (the color of the surface varies at times), in addition, of course, to the change produced by the rotation of the planet. These variations are probably due to the atmosphere of the planet, laden with clouds and mists, obscuring more or less of the underlying features of the planet. By comparison of drawings made from time to time, maps have been made giving the permanent features of the planet's surface. There seems, so far as we can judge, a much greater proportion of land to sea than is the case with the earth, few great continents and oceans, but numerous narrow "seas" penetrating and dividing the "land." But the most remarkable features of this planet's surface are a series of long, straight markings connecting the larger "seas," first seen by Schiaparelli in 1877, to which he gave the name of "canals." In 1881 he saw them again, and this time many of these canals were double. Some of his observations have been confirmed by other astronomers; and others, again, have denied the existence of these canals, or, at least, their duplicity. M. Terby considers the "double canals" to be purely an optical phenomenon, and remarks that they present exactly the appearance that single markings would present if viewed through a double-image prism. Some experiments made by Mr. Maunder at Greenwich point to a

similar conclusion. On the other hand, Prof. Lowell, firmly convinced of the reality of these markings, regards them as artificial works due to Martian engineers. He considers that the planet is now all but devoid of water, none remaining but a little in the polar regions. When the "snow-caps" melt, the canals convey the precious fluid toward the equator, and vegetation bursting round their banks produces the periodical changes of tint that we see.

However, there is considerable uncertainty as to the true nature of these polar caps. At first it was thought, from terrestrial analogies, that these were composed of snow, melting on the approach of the planet's summer; yet there is much reason to suppose that they may consist of solid carbon dioxide, which much resembles snow in appearance, and evaporates at a very much lower temperature. The atmosphere of Mars is probably much rarer than our own, and, being considerably farther from the sun, both winter and summer temperatures must be lower; but yet the polar caps diminish to a much greater extent than could be expected. Dr. Johnstone Stoney supposes, accordingly, that it is solid carbon dioxide (carbonic acid gas frozen), and not snow, of which they are composed.

Thus all the evidence we possess seems to point to this planet being a much older one than our own. If we suppose both earth and Mars originally incandescent bodies, the much smaller planet would cool more quickly, and it would grow old and decrepit much sooner.

The spectroscope shows the presence of water-vapor in the Martian atmosphere, and some are of opinion that there is a very considerable amount of it; but most observers consider that the amount both of air and water is considerably less, not merely absolutely, but in proportion to its bulk, than on our planet.

Though some enthusiastic observers are convinced of the existence of rational beings, in an advanced state of civilization, inhabiting Mars, we may well pause before we arrive at this conclusion. All the evidence we certainly possess so far merely indicates the possibility of a narrow equatorial zone being the abode of life, at least of a kind akin to that with which we are familiar. If the polar caps be composed of solid carbon dioxide, the temperature prevailing during the planet's winter seasons must be excessively low. Nevertheless, this by no means precludes the possibility of the existence of races of beings of a totally different character to anything we can imagine.—English Mechanic and World of Science.

MOISTURE AND CHEMICAL CHANGE.*

HOW WATER AFFECTS CHEMICAL REACTIONS.

BY DR. H. BRERETON BAKER, F.R.S.

THE influence of a trace of water vapor on a chemical reaction was first noticed by Prof. H. B. Dixon in 1880. He found that it was possible to pass electric sparks in a mixture of carbon monoxide and oxygen without explosion if the mixture had been very carefully dried. Shortly afterward Cowper proved that dried chlorine had little or no action on several metals. Further observations were made by Prof. Dixon's pupils, the author in 1884 showing that carbon could be heated red hot in dried oxygen, that sulphur, and even the very inflammable phosphorus, could be distilled in the same gas without burning. Later experiments proved that ammonia and hydrogen chloride gases could be mixed without uniting, and that the readily dissociated ammonium chloride could be converted into a true vapor, and sulphur trioxide could be crystallized on lime, provided always that moisture was, so far as possible, removed. In 1902 it was shown that tubes containing very dry and pure hydrogen and oxygen could be heated to redness without any explosion resulting, and in 1907 that nitrogen trioxide could exist in the gaseous state if carefully dried.

Taken altogether, some twenty-five simple chemical actions have been shown to be dependent on the presence of moisture, and a few only, the burning of cyanogen, carbon bisulphide, and some hydrocarbons, seem to take place as easily when dried as when moist. In 1893 Sir J. J. Thomson showed that a potential difference of 1,200 volts was unable to cause the passage of electric sparks through very dry hydrogen, and in the same year the author was able to stop the passage of the discharge from an induction coil by carefully drying the gas between the platinum points.

The amount of water necessary for the bringing about of chemical action is extremely small, less, in all probability, than one part in three hundred thousand of the reacting gases. Many hypotheses have been suggested for the explanation of its action. Prof. Dixon believed, in the case of carbon monoxide and oxygen, that the water vapor acted as a carrier of oxygen by alternate reduction and re-oxidation of the hydrogen. Traube imagined an alternate formation and decomposition of hydrogen peroxide. Dr. Armstrong in 1884 suggested a theory of "reversed electrolysis," the impurity of the water vapor rendering it a conductor. Sir J. J. Thomson in 1893 published a paper showing that if the forces holding the atoms of a molecule together were electrical in their nature, these forces would be very much weakened in presence of liquid drops of any substance of high specific inductive capacity such as water.

In 1895 it was shown that the newly discovered Röntgen rays were able to cause a gas to become a conductor of electricity, and it was thought, at that time, that the molecules of the gas were split up into atoms by this agency. If this were so, it seemed likely that in these circumstances chemical action would take place in absence of water, but a joint paper of Prof. Dixon and the author, in 1896, showed that the Röntgen rays, at the ordinary temperature, had no measurable effect on the combination of dried gases. Since that time, however, the researches of J. J. Thomson, Rutherford, Townsend, and others have proved that the ionization of gases is of a different character.† The negative ions are extremely small particles of the mass of about 1/1000th part of the mass of an atom of hydrogen, the positive ion being the residue, but whether it is the residue of a molecule or of an atom seems to be still doubtful.

With the view of illustrating the influence of ionization of gases on chemical change, the author devised a new experiment. It is known that mercury vapor, in ordinary circumstances, contains only atoms of mercury, which exhibit little tendency to combine with oxygen. The vapor, however, is ionized in the mercury vapor lamp, and when the current is cut off and oxygen is admitted shortly afterward, the mercury becomes covered with a layer of mercuric oxide. Since the temperature of the lamp is much below that at which ordinary mercury vapor combines with oxygen, it is evident that in this case ionization can bring about chemical action.

It is probable that this ionization of mercury is different from the ordinary ionization of gases. It may be regarded as the splitting off of an electron from the atom as distinct from a molecule, and the charged atom of mercury can then enter into union with oxygen. The cases mentioned above of combustions in oxygen which are apparently unaffected by the absence of moisture are perhaps to be explained in the same way. The gases are readily broken up into their elements, and it has been shown that carbon bisulphide breaks up at a lower temperature than that required for its burning. When these gases are heated charged atoms are probably formed, capable of direct union with oxygen.

To test further the question as to whether the ionization of molecules, as distinct from atoms, as in the case of mercury vapor, can bring about chemical change, some recent experiments have been performed in which radium bromide was used as the ionizing agent. Small quantities of this salt, contained in open silica tubes, were sealed up in tubes containing mixtures of hydrogen and oxygen and carbon monoxide and oxygen, the gases being very dry in some cases and moist in others. In no case was any chemical action observed, although the tubes were allowed to stand at 20 deg. for more than two months. By means of a vacuum gage the combination of 1/10,000th of the whole could have been detected. Another experiment showed that radium bromide was able to produce ionization in very dry air, so that the want of chemical action in the above experiments must have been due to the fact that ionization cannot of itself produce chemical action. There remained, however, the possibility of ionization increasing the rate of union of two gases which were otherwise under conditions which would produce a slow chemical action between them. The reaction between nitrous oxide and hydrogen was found to be a suitable one for investigation, since it takes place slowly and uniformly at 530 deg. It is known that many substances will, when heated, ionize gases. Lime is fairly effective in this respect, thoria to a much greater extent, and radium bromide is the most effective of all. Accordingly, tubes containing the mixture of not very dry hydrogen and nitrous oxide were prepared. One contained a little lime, a second some thoria, and a third some radium bromide. These tubes were heated in an electric resistance furnace side by side with comparative tubes containing the same gases in which was a small quantity of powdered Jena glass to make the conditions as similar as possible. It was found that the rate of combination was much quickened by the presence of lime, much more by the presence of thoria, while the gases in contact with radium bromide, directly the combining temperature was reached, combined with explosion.

When a tube containing thoria and the same mixture was dried for ten days by phosphorus pentoxide, the gases showed no measurable combination when heated for five minutes to 530 deg.

Hence increasing the ionization in presence of moisture increases the rate of chemical change, while in absence of moisture it apparently has no effect.

An experiment of rather different type was shown which illustrates the way in which the ionization of gases may exert its influence. A mixture of sulphur dioxide and sulphureted hydrogen can be kept unchanged although water vapor is present in some quantity. If, however, liquid water is introduced, separation of sulphur is immediate. A small open tube of radium bromide was placed in such a mixture, and after standing some time the whole of the gases condensed in the small tube of radium bromide in the form of sulphur and water. There is little doubt as to what happens in this case; the water vapor condenses in liquid drops on the ionized particles in the radium tube, and in these drops the reaction between the two gases is completed.* In the other chemical changes at high temperatures it is conceivable that condensation to some form approaching the liquid state might take place, in which case Sir J. J. Thomson's theory would apply.

In support of this view must be mentioned some very recent experiments of Prof. J. S. Townsend, which show that a very great diminution in mobility of negative ions is produced when a mere trace of water vapor is added to a dried gas ionized by Röntgen rays. If there is any truth in this provisional working hypothesis, it should be found that ions and water vapor (or some similar substance) must both be present in a mixture of gases if action is to take place. Experiments already in progress seem to show that this is the case, but they have not been sufficiently often repeated for it to be desirable to publish the results at this stage.

The nature of combustion is only beginning to be understood. It is still currently believed that hydrogen and carbon monoxide necessarily and spontaneously burst into flame on coming into contact with oxygen at a high temperature, but Dixon discovered in 1883 that this mixture of gases is not inflammable when perfectly dry. Not only is the presence of moisture necessary for combustion, but up to a certain limit the amount of oxidation depends upon the degree of humidity. Faraday had demonstrated long before this the absolute identity of chemical and electrical actions. Hence the same conditions are required for the production of chemical changes and of electrical currents. The most important of these conditions is the presence of a conductor or electrolyte. Pure water is not a conductor, so that some substance which will make it a conductor must be present also. In 1902, Brereton Baker proved that a mixture of pure hydrogen and oxygen could be raised to a red heat in presence of pure water without exploding. The water present in the usual conditions of experiment contains impurites which insure conduction and hence effect chemical combustion.

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* Abstract of the Wilde lecture, delivered before the Manchester Literary and Philosophical Society.

† The author finds that liquid water invariably collects in tubes containing salts of radium, though these salts are not at all deliquescent. In one experiment 10 milligrammes of radium bromide increased in weight by 1.5 milligramme when allowed to stand for two days in an atmosphere saturated with moisture at 0 deg. C. Examination of the crystals under the microscope showed that their edges were quite sharp, showing that the absorption of water was not due to deliquescence.

* Since the phenomenon in gases is admittedly different from that in electrolysis, it is much to be regretted that the same term, ionization, is retained for both.

ENGINEERING NOTES.

The Tauerun tunnel, more than five miles in length, which forms a connecting link in the new railway line from Salzburg to Trieste, was first traversed by a locomotive on February 27th of this year. The railway will be completed and put into operation without delay.

According to the Engineering Record, a jib derrick commanding a full circle of 75 feet radius is in use in St. Louis for handling logs. It has a capacity of 5 tons, and the hoisting, revolving, and traversing of the trolley are done by electric motors. The mast is 60 feet long, and is supported at the top by two horizontal struts running to triangular towers. The framework is entirely of structural steel. The maximum hoisting speed is 120 feet per minute and the trolley speed 150 feet per minute.

The earthquake-resisting qualities of reinforced concrete, already proved in San Francisco, have received a fresh demonstration in Messina, where buildings constructed of this material remained uninjured, even in those parts of the city which were most severely visited by the recent earthquake. A dwelling built of reinforced concrete was the only building left standing, and its occupants were the sole survivors of a large section which was reduced to ruins. The reservoir of reinforced concrete was entirely uninjured and the water supply was not interrupted for an instant.

In a report submitted at the convention of the International Union of Street and Interurban Railways, held in Munich a few months ago, it is noted that several German street railway lines have been using reinforced concrete cross sleepers upward of four years, and the results have been entirely satisfactory. The sleepers are 7.2 feet long, weigh 308 pounds, and cost about 6s. each. The concrete is composed of 33 per cent cement and 66 per cent gravel, and the reinforcement consists of five round bars ⅝ inch thick. Their great weight lends stability, the rail fastenings are very secure, and there is but little wear caused. They promise to have a much longer life than wooden sleepers, and are considered by a great many to possess advantages over the much-looked-to metal sleeper.

Bulletin No. 26 on High Steam Pressures in Locomotive Service has just been issued by the University of Illinois Engineering Experiment Station. It is an abstract of a report upon the same subject, which was published last year by the Carnegie Institution of Washington, D. C. It summarizes the results of the hundred locomotive tests conducted by Dr. W. F. M. Goss under the patronage of the Carnegie Institution in co-operation with the authorities of Purdue University. The tests were run in six different series, the boiler pressures for the several series varying from 120 pounds to 240 pounds. The results presented include concise statements concerning the effect of changes in boiler pressure upon power capacity and upon steam and coal consumption per unit power developed. The general question is discussed as to whether a possible increase in the weight of a boiler should be utilized by making the boiler stronger that it may carry a higher pressure, or by making it bigger that it may have more heating surface. The conclusion of this discussion, based upon data presented, is to the effect that single-expansion locomotives using saturated steam are most efficient when operated under a boiler pressure of 180 pounds; that when this limit of pressure has been reached, any further increase in weight which may be possible should be utilized in securing increased boiler capacity rather than higher boiler pressures.

SCIENCE NOTES.

In order to increase the efficiency of mercury vapor lamps, quartz tubes are used in place of glass tubes. An interesting method of making these tubes has just been patented. A carbon mold is imbedded in granulated quartz, and then heated by passing a current therethrough until the quartz is fused about it. The tube is now cooled, and by means of an electric arc the carbon is burned off, leaving a quartz shell.

Inquiry as to the general age of trees being put to an authority at Washington, it was found that the pine tree attained 700 years as a maximum length of life; 425 years was the allotted span of the silver fir; the larch lived 275 years, the red beech 245, the aspen 210, the birch 200, the ash 170, the elder 145, the elm 130. The heart of the oak begins to rot at about the age of 300 years. Of the holly, it is said that there is a specimen 410 years old, near Aschaffenburg, Germany.

In a recent number of Comptes Rendus, E. Estanave suggests a method of obtaining stereoscopic effects by direct vision. Take one negative by means of two lenses whose images coincide; interpose a ruled screen so that the black lines of this cut out linear strips of one image, while the linear spaces thus left are filled in by linear strips of the other image. The product is thus a single negative presenting linear strips belonging to the two images alternately. Reverse this before fixation so as to make a positive transparency. On assembling the screen, the positive and a piece of ground glass, in proper register and looking through (screen toward the eye) a distance will be found at which each eye sees only its own component of the mixed positive, and the appearance is one of relief. The registration is, however, troublesome; and Estanava simplifies by making the black-and-clear ruled screen on one side of a glass plate, coating the other side with emulsion, taking the photograph through the glass, developing, reversing, fixing, and then coating with matt varnish. An autochrome plate may have a screen at the back of its glass (before being coated with its starch and emulsion) with similar effect in colors.

On the subject of the recent statement of M. Camille Flammarion concerning the daily undulations of the earth, the Kimberley Diamond Fields Advertiser remarks: "A regular undulation of the earth's surface is particularly well marked in Kimberley, and has been under investigation at Kenilworth for some years past. There are some delicate pieces of apparatus at Kenilworth Observatory, by means of which the slightest change of level can be detected, and they have shown that the solid crust of the earth is never at rest, but rises and falls once (not twice) a day. This undulation is not tidal; it is connected most likely only with the sun, and not at all with the moon, and is certainly of a greater range, in this part of the world at any rate, than 8 inches a day. We do not notice this rise and fall, because it takes place gradually throughout the whole day, but it is of a magnitude that dwarfs by comparison the movements of the greatest of earthquakes. Were it to come all at once instead of gradually, nothing on earth could stand for a single instant. One further fact revealed by the investigations at Kenilworth is that in addition to the daily vertical movement there is an annual one, traceable probably to the seasonable incidence of rainfall over South Africa, and because of which the whole sub-continent tilts to the east in summer and to the west in winter; so that on the whole it may be for the present assumed that Prof. Flammarion's information is neither very new nor very true."

TRADE NOTES AND FORMULÆ.

Fluid Siccative.—60 parts of old linseed oil are boiled with 3 parts of carbonate of manganese until viscid. The temperature required is about 536 deg. F. (280 deg. C.). The mass should then be dissolved in 120 parts or more of oil of turpentine.

Siccative Oil.—100 parts of sugar of lead is rubbed down to a very fine powder and thoroughly mixed with 1,200 parts of poppy oil. The mixture is exposed in a white glass bottle to the effects of the sunshine, being frequently thoroughly shaken. By this means it is possible to produce an almost colorless oil, which after mixture with 250 parts of turpentine dries very quickly. The varnish coat is solid and durable.

Siccative is obtained by precipitating 70 parts of super phosphate of lime and 20 parts of super phosphate of magnesia, by means of soda. The precipitated and intimately mixed precipitate of phosphate of lime—magnesia—is of the greatest fineness and after drying forms a bright hygroscopic powder that possesses marked drying properties. By the addition of a manganese salt, about 10 parts of pure borate of manganese, the drying faculty may be increased.

Cracking Coal for Cutting Glass.—Take 8 parts of finely pulverized brown coal, sifted through gauze, and mix it with half a part of sugar of lead pulverized as finely as possible. With the addition of tragacanth mucilage this forms a stiff paste, of which the cracking carbons are formed in the shape of elongated rods, and dried. Such a coal, when perfectly dried, will break off the object to be cut very evenly.

Yellow Varnish for Windows of Dark Rooms.—This is made by dissolving 5 parts of xanthorrhœa or acaroid gum in 5 parts of 95 per cent alcohol. When solution has been effected, it is advisable to add about a quarter of a part of copaiba balsam, or castor oil, to prevent the cracking or peeling off of the gum coating. This will not permit the passage of any chemically effective rays of light and is to be preferred to the ordinary gold varnish because it does not bleach out in the light.

Metallic Inks.—In the popular colored inks, aniline colors play an important part. According to Viedt, red ink is prepared by dissolving 1 part of diamond fuchsine in 150 to 200 parts of boiling water; blue ink, by dissolving 1 part of water-soluble *bleu de nuit* in 200 to 250 parts of boiling water; violet ink, by dissolving 1 part of blue violet, soluble in water, in 300 parts of water. To make green aniline ink, dissolve 1 part of iodine green in 100 to 110 parts of boiling water. Yellow aniline ink is not to be recommended; to make it, dissolve 1 part picric acid in 120 to 140 parts of water. All the inks flow nicely from the pen without spotting and the addition of gum is therefore not necessary.

Koppel's non-dangerous explosive is made of two kinds: No. I, intended for hard, No. II, for softer rock. Their composition is as follows: Nitrate of potash I 35 parts, II 42 parts; nitrate of soda I 19 parts, II 22 parts; refined sulphur I 11 parts, II 12.5 parts; sawdust I 9.5 parts, II 19 parts; chlorate of potash I 9.5 parts; wood charcoal I 6 parts, II 7 parts; sulphate of soda I 4.25 parts, II 5 parts; prussiate of potash I 2.25 parts; refined sugar I 2.25 parts; picric acid I 1.15 parts, II 1.5 parts. Each of the ingredients is separately pulverized; they are then mixed in a wooden cylinder, the mixture moistened with 10 to 15 per cent of water and stirred thoroughly until sufficently large pieces are formed, which are slowly dried and freed from dust in sieves. The advantages of this explosive are its cheapness and non-susceptibility to friction and shock. It explodes only on contact with red-hot or flaming bodies.

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